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VOL. XXI *JANUARY–OCTOBER*, 1921 NOS. 1–4

## AN EXPERIMENTAL STUDY OF THE CATHODE FALL IN HELIUM AND ARGON WITH WIRE CATHODES

BY L. G. RAUB

It was recognized rather early in the study of the phenomena of discharge of electricity through gases that the ordinary laws of conduction as found in solid and liquid conductors are not applicable to gases. It was shown by Zeleny[1] and independently by Child[2] that Ohm's law by no means represents the distribution of potential between electrodes in an ionized gas, but that the potential gradient is large in the vicinity of the electrodes, and not uniform throughout the space between them.

When the pressure of the gas surrounding the electrodes is reduced to one or two millimeters and a current passed between the electrodes, part of the intervening gas becomes luminous and part does not show any luminosity. In this case the potential gradient through the gas is decidedly irregular.

Covering the surface of the cathode is a thin, luminous layer of gas called the "cathode glow." Beyond the cathode glow is a layer of non-luminous gas known as the Crooke's dark space followed by a layer of luminous gas, the negative glow. At the surface of the anode is a layer of luminous gas, the positive column, the extent of which depends upon the length of the tube and the pressure of the gas—the length of the positive column being made shorter either by lowering the pressure of the gas or making the tube shorter. Between the negative glow and the

[1] Zeleny, *Phil. Mag.*, Vol. 46, p. 120, 1898.
[2] Child, *Wied. Ann.*, Vol. 65, p. 152, 1898.

positive column is a second layer of non-luminous gas known as the Faraday dark space.

The extent of the cathode glow is not materially changed by a change of pressure or current. However, the negative glow and the Crooke's dark space increase in length as the pressure is reduced. If the exhaustion is carried to an extreme limit as in an X-ray bulb, the Crooke's dark space fills the entire tube and the glass walls begin to fluoresce.

The electric intensity varies greatly in the different parts of the tube and has been investigated by Hittorf,[3] Graham,[4] Skinner,[5] Wilson,[6] and many others. The usual method of measurement is to insert a small wire electrode in the gas and measure the potential at that point. From the potential difference between one electrode and some point in the gas or between two points in the gas the electric intensity may be determined.

Investigation has shown that there is a large potential drop between the cathode and the edge of the negative glow amounting in general to rather more than two hundred volts. This relatively large drop of potential is known as the cathode fall.

When the current density is small enough so that the glow does not entirely cover the cathode, the cathode fall is independent of the current and is known as the normal cathode fall. As the current is increased the glow covers more of the cathode surface—and the cathode fall remains constant—until it is entirely covered, after which any further increase of current causes an increase in the cathode fall.

In the luminous negative glow the potential gradient is very small, gradually rising as one progresses from the negative glow through the Faraday dark space to the positive column, in which the gradient becomes fairly uniform up to a point relatively close to the anode, at which a second abrupt potential fall—by no means as large as that at the cathode—is found which is termed the anode fall.

The cathode fall has been the subject of much research and no

[3] Hittorf, *Wied. Ann.*, 20, p. 705, 1883.
[4] Graham, *Wied. Ann.*, 64, p. 49, 1898.
[5] C. A. Skinner, *Wied. Ann.*, 68, p. 572, 1899.
[6] H. A. Wilson, *Phil. Mag.*, 49, p. 505, 1900.

explanation has been entirely satisfactory. It has been found to consist of two distinct, but interdependent, parts: (*a*) the potential difference between the surface of the cathode and a point in the gas very near the cathode, this point being marked by the outer edge of the cathode glow; and (*b*) the potential difference between this point and the negative glow, or point of minimum potential gradient. Of these quantities (*a*) the polarization potential difference due to the accumulation of positive ions at the surface of the cathode is, in general, the larger quantity and increases with increasing current density. The cathode glow, within which this drop occurs, is about .2 mm. in thickness and does not seem to vary appreciably with the current density. The magnitude of (*a*) appears to be proportional to the potential gradient of the positive ions just before they enter the polarization region.[7] The difference in potential between the cathode glow and the negative glow can not be explained as readily, and it is the explanation of this potential difference in which we are interested.

Stark[8] has given a theory connecting the cathode fall for any current density with the normal cathode fall, the normal current density—*i.e.*, the current density which is just sufficient to cause the glow to cover the surface of the cathode—the gas pressure, the cathode area, the current, and the absolute temperature. This theory is fairly satisfactory, but does not at all explain the drop of potential through the Crooke's dark space.

In 1915 Skinner[9] published a theory of the cathode fall in which he obtained expressions for the upper and lower limits, giving the difference of potential between the cathode and a point in the gas between the cathode and the point of minimum potential gradient. In a later article he obtained a simpler and more exact theory[10] which is applicable to both plate and wire cathodes.

A description of the process which is conceived to go on between the cathode and outer edge of the negative glow will give us a basis for the theory obtained. Under the bombardment of

[7] C. A. Skinner, *Phys. Rev.*, IX, pp. 97 and 314, 1917.
C. A. Skinner, *Phys. Rev.*, XII, p. 136, 1918.
[8] J. Stark, *Ann. d. Physik*, 12, p. 1, 1903.
[9] C. A. Skinner, *Phys. Rev.*, V, p. 483, 1915.
[10] C. A. Skinner, *Phys. Rev.*, XII, p. 143, 1918.

the positive ions the cathode liberates a small electron current—of the order of $10^{-8}$ amp. per cm.$^2$. Driven by the intense electric field these electrons double in number at every ionizing collision, producing at the same time an equal number of positive ions. The negative current, then—since we may safely assume no recombination of ions—at any point in the gas is determined by the number of electrons produced per second from the cathode up to that given point in the gas. Likewise, the positive current at any point is determined by the number of positive ions per second entering from the negative glow, plus the number of positive ions produced per second by the collisions of the electrons between the point considered and the negative glow. Conditions in the negative glow allow a relative evaluation of these two currents. The potential gradient in the negative glow being very small, the density of charge is practically zero, which means that the volume charge of electricity of both signs have equal density. Since the potential gradient is very small, the mobilities of the positive and negative ions may be assumed equal. Equal densities of charge and equal mobilities give equal positive and negative currents.

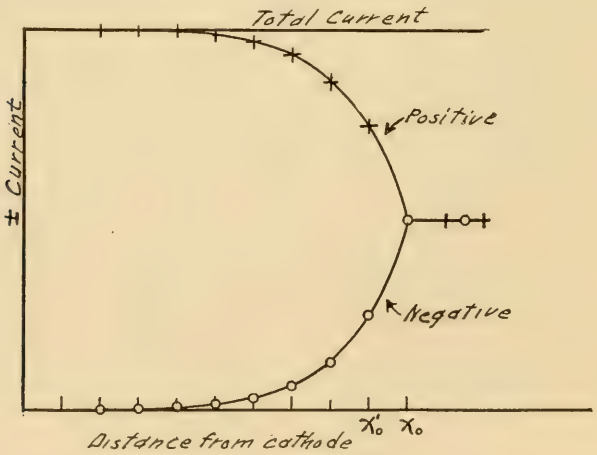


FIG. 1

Figure 1 illustrates what we may conceive to occur in an ideal case where the ionizing intervals are equal and the negative glow

is considered to be the sole source of ions. In the negative glow where the positive and negative currents are equal the horizontal portion of the curves represents the value of the current due to either type of ions. If $X_0$ is assumed as the source of ions, then at one ionizing interval toward the cathode, $X_0'$, the negative current will have dropped to one-half its original value, or one-fourth the total current, and the positive current will be three-fourths the total current. At two ionizing intervals the negative current will be one-eighth the total current, while the positive current will be seven-eighths, and so on until the positive ions are carrying practically all the current.

Assuming the negative glow to be the sole source of ions leads to the development of a relatively simple theory of the potential at different points in the gas, between the cathode glow and the negative glow. The results of the theory obtained agree very closely with the experimental measurements made.

## THEORY OF THE POTENTIAL FALL

If we assume the source of positive ions, $X_0$, to be an infinite equipotential plane surface, and that between it and the polarization region, $X_a$, of an infinite plane cathode, there is a uniform current density, $j$, of positive ions, with the potential gradient $\delta V/\delta X$ at $X_0$ equal to zero, Poisson's Law for density of charge, since the planes are parallel, gives

$$\frac{\partial^2 V}{\partial X^2} = -4\pi ne, \tag{1}$$

where $n$ is the number of positive ions per c.c. and $e$ the ionic charge. From the law of the mobility of the ions we have the current density

$$j = -neU\frac{\partial V}{\partial X}, \tag{2}$$

where $U$ is the mobility, or velocity of the ions in cm. per sec. for a potential gradient of one volt per cm.

If the source of ions and the polarization region are infinitely long, concentric cylindrical surfaces, the Poisson equation becomes

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V}{\partial r}\right) = -4\pi ne, \tag{3}$$

where $r$ is the radius of the equipotential surface having the potential $V$.

If now we substitute the current per unit length of cathode,

$$I_1 = 2\pi rj$$

for $j$ in (2) we obtain an expression for the difference of potential between the cathode and a point in the gas between the source of ions, $r_0$, and the cathode glow, namely,

$$I_1 = -2\pi rneU\frac{\partial V}{\partial r}. \tag{4}$$

Equation (3) is expressed in electrostatic units; in practical units it becomes

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V}{\partial r}\right) = -3.6 \times 10^{12}\pi ne. \tag{5}$$

Solving for $\delta V/\delta r$ by use of (4) and (5) and making use of the fact that if $r \equiv r_0$, $\delta V/\delta r = 0$, we have

$$\frac{\partial V}{\partial r} = 1.34 \times 10^6\left(\frac{I_1}{U}\right)^{1/2}\left[\frac{r^2 - r_0^2}{r^2}\right]^{1/2}. \tag{6}$$

This equation requires that $I_1$ be negative, as it should be, for the direction of flow of the positive electricity is in the direction of decreasing gradient. However, for convenience we wish to use $I_1$ as a positive quantity, and (6) becomes

$$\frac{\partial V}{\partial r} = 1.34 \times 10^6\left(\frac{I_1}{U}\right)^{1/2}\left[\frac{r_0^2 - r^2}{r^2}\right]^{1/2}. \tag{7}$$

Solving (7) for $V$ and making use of the fact that when $r \equiv r_0$, $V = V_0$, we have

$$V_0 - V = 1.34 \times 10^6\left(\frac{I_1}{U}\right)^{1/2}\left[r_0 \log\frac{r_0 + \sqrt{r_0^2 - r^2}}{r} - \sqrt{r_0^2 - r^2}\right], \tag{8}$$

where $V$ is the potential at any radius $r$ between the source of ions $r_0$ and the polarization region at the cathode.

The purpose of the present investigation is to test the above theory—which is a simpler mathematical expression of Skinner's theory—in the monatomic gases helium and argon.

*Apparatus.*—The apparatus used was similar to that used by Skinner.[11] It consisted of a cylindrical tube 3 cm. in diameter with a wire cathode $K$ lying in its axis (Fig. 2). The cathode

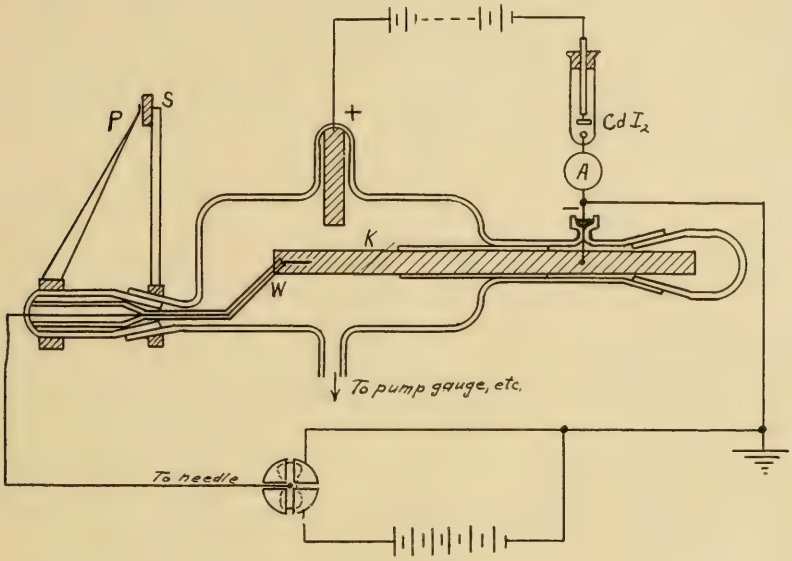


FIG. 2

was partly covered by a glass sheath which confined the discharge to a definite area. The anode was an aluminium wire placed in a side tube as shown in the figure. The potentials in the gas were measured by means of the probe-wire, $W$, which could be shifted to any position in the gas, since its axis of rotation is parallel to $K$. The probe was sheathed by a glass tube except for the short part of its length parallel to $K$. The diameter of the circle described by the probe is 20 mm. and its position is obtained by the pointer $P$ moving over a circle of reference $S$—having a diameter of 30 cm. $S$ is so adjusted that its zero corresponds to the center of $K$, and thus the distance from the center of $K$, or the radius of the equipotential surface, is given directly by readings on $S$.

[11] C. A. Skinner, *Phys. Rev.*, XII, No. 2, p. 143, 1918.

Certain systematic errors arise in measuring the distance from the center of $K$ to the probe. One is due to the impossibility of determining when the probe passes through the axis of the cathode. This was obtained as accurately as possible by drawing $K$ back until the probe would rotate past the end and adjusting $S$ while the probe-wire was held at the center of the cathode. A second error arises from the impossibility of making the probe exactly straight and exactly parallel to the axis of the cathode. These errors were made sufficiently small to be negligible except at points very near the cathode surface. However, the deviations found at the edge of the polarization region are consistent and would seem to arise from these errors.

A third error which is not systematic and has a greater effect upon the computed results arises from the difficulty in locating the point of minimum gradient, $r_0$, of equation (8). This value, which has a great influence on the computed potentials, is not well marked by the luminosity in the gases used. It was determined, approximately, by taking several readings in this region and plotting observed potentials against distances, or radii of the equipotential surfaces. The most probable values of $r_0$ and $V_0$ were then taken from this curve and substituted in equation (8), together with the values of two or three other equipotential surfaces not too near the negative glow. The value of the factor $1.34 \times 10^6 (I_1/U)^{\frac{1}{2}}$ was then computed, and those values of $r_0$ and $V_0$ which gave most nearly a constant value for this factor were taken as corresponding to the point of minimum gradient. The average of the values obtained by the above computation for the factor $1.34 \times 10^6 (I_1/U)^{\frac{1}{2}}$ was then used in computing the values of $V$ recorded in the tables.

The current was furnished by a battery of small lead storage cells and measured by a Weston milliameter (Fig. 2). The difference of potential between the cathode and the probe was measured by a well-insulated quadrant electrometer of the Dolazalek type with a phosphor-bronze needle suspension. The cathode was an aluminium wire carefully cleaned and polished.

The apparatus for generating and purifying helium is shown in Fig. 3. Dry, powdered clevite was placed in flask $A$, and granular

potassium hydrate and phosphorus pentoxide in the bulbs *B* and *C*, respectively. The system was evacuated and the clevite in *A* was heated over a sand bath. The increase in pressure was measured

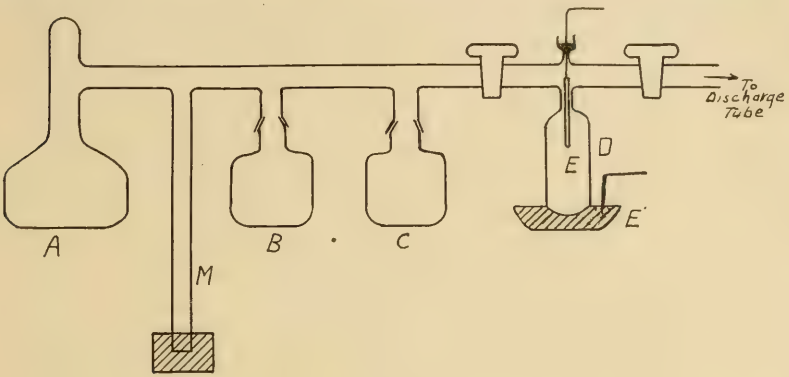


FIG. 3

by the manometer, *M*. The gas thus generated, which is mainly helium with hydrogen, oxygen, nitrogen and water vapor as impurities, was allowed to stand for at least twenty-four hours in the drying bulbs *B* and *C*.

Having removed the water vapor from the gas, it was allowed to enter the purifying chamber *D*. This was a discharge tube with an aluminium wire, *E*, as one electrode and an alloy of metallic potassium, sodium, and mercury for the second electrode, *E'*. *E'* was heated to about 300° C., at which temperature the glass becomes sufficiently conducting so that potassium and sodium were passed through the glass into the chamber by electrolysis. The current was then reversed and a glow current maintained in the tube using the alloy, *E'*, as cathode.[12] According to Mey,[13] this treatment eliminates nitrogen, oxygen, and hydrogen, leaving only argon as an impurity. The writer was able to remove all traces of oxygen and hydrogen so that spectroscopic examination failed to show any trace of either gas. Nitrogen, however, was

[12] Much trouble was encountered in the purification because the glass deteriorated and cracked while the current was passing through it. Several samples of helium were lost in this way.

[13] K. Mey, *Ann. d. Physik*, (4) 11, p. 127, 1903.

not completely eliminated, and after the current had been passed for several hours spectroscopic observations always revealed, more or less faintly, the characteristic flutings of nitrogen, with the helium lines standing out strong and sharp. According to Ramsay,[14] one-hundredth of one per cent. of nitrogen is still visible in

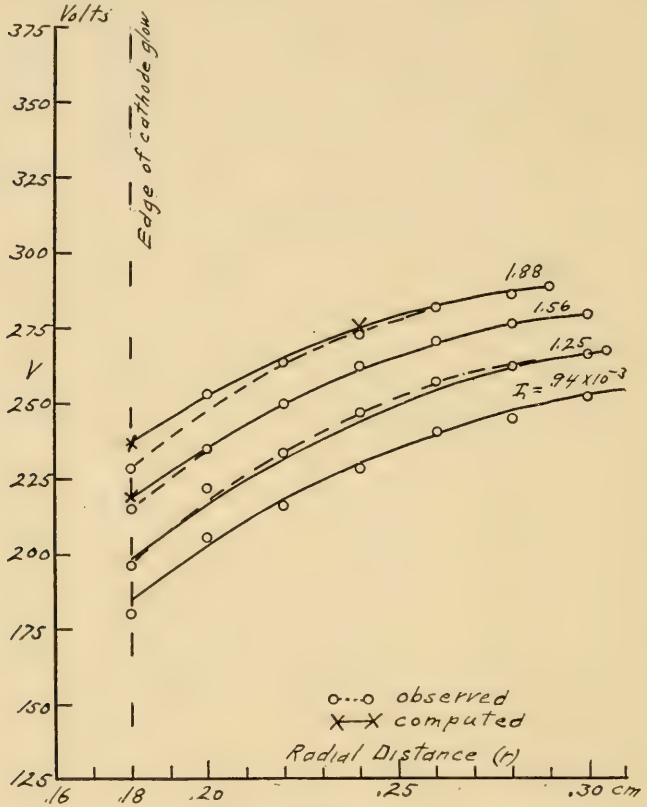


FIG. 4

helium, so that it seems probable that in the samples used there were only a few hundredths of one per cent. of nitrogen at the most present as an impurity.

[14] Ramsay, *Proc. Roy. Soc.*, 59, p. 325, 1896.

EXPERIMENTAL RESULTS

*Helium.*—Table I gives the observed potentials at different distances from the axis of the cathode and the corresponding values of the potential computed from the theoretical formula (8), for helium at a pressure of 2.55 mm. for four different current densities. These are shown graphically in Fig. 4. The values of $r_0$ and $V_0$, the value of $V$ at the bottom of each column, were determined as described above. In the first column is given the distance of the equipotential surface from the axis of the cathode. The observed values of the potential are in reasonably good agreement with the computed and none of them could be called distinctly unsatisfactory except the one for the point nearest to the cathode for the greatest current density. Since nearly all the measurements at that position have shown a considerable error, it seems probable either that the errors due to the orientation of the probe make these readings unreliable or that the setting for that position is slightly within the polarization region. Confidence in

TABLE I

*Aluminium Wire Cathode*

Diam., 3.2 mm.; exposed length, 3.2 cm.; Helium pressure = 2.55 mm.

| Dist. | $I_1 = .94 \times 10^{-3}$ Amp. | | $I_1 = 1.25 \times 10^{-3}$ Amp. | | $I_1 = 1.56 \times 10^{-3}$ Amp. | | $I_1 = 1.88 \times 10^{-3}$ Amp. | |
|---|---|---|---|---|---|---|---|---|
| ($r$) | $V$ | | $V$ | | $V$ | | $V$ | |
| Cm. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. |
| .18.... | 180.0 | 184.9 | 196.1 | 197.9 | 214.5 | 218.6 | 228.5 | 237.3 |
| .20.... | 205.3 | 202.8 | 221.5 | 216.4 | 234.6 | 234.9 | 252.7 | 252.6 |
| .22.... | 216.5 | 217.8 | 233.4 | 231.3 | 249.7 | 249.2 | 263.5 | 265.0 |
| .24.... | 228.0 | 230.6 | 246.5 | 244.5 | 262.1 | 260.5 | 272.5 | 275.0 |
| .26.... | 239.9 | 240.2 | 256.7 | 254.6 | 270.3 | 269.5 | 281.5 | 282.6 |
| .28.... | 244.7 | 248.1 | 262.2 | 262.0 | 276.0 | 275.6 | 286.0 | 287.3 |
| .29.... | ..... | ..... | ..... | ..... | ..... | ..... | 288.5 | 288.5 |
| .30.... | 252.0 | 253.4 | 266.2 | 266.4 | 279.0 | 279.0 | | |
| .305 ... | ..... | ..... | 267.1 | 267.1 | | | | |
| .31.... | 254.2 | 254.2 | | | | | | |
| U..... | $3.56 \times 10^3$ | | $4.23 \times 10^3$ | | $6.14 \times 10^3$ | | $8.04 \times 10^3$ | |
| $U_1$..... | $9.7 \times 10^3$ | | $10.79 \times 10^3$ | | $15.66 \times 10^3$ | | $20.5 \times 10^3$ | |

*

the probable truth of the latter suggestion is strengthened when it

is noted that in the great majority of instances the observed values at this point are lower than those calculated.

In Table II are given the observed and calculated potentials in helium at a pressure of 1.55 mm., with a graphical representation in Fig. 5. The results show a reasonably good agreement except

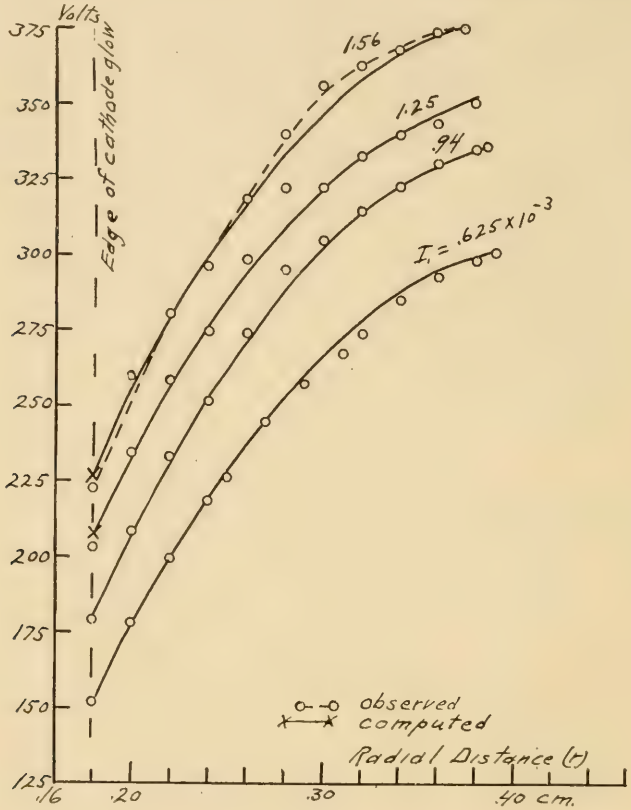


FIG. 5

for one reading in the next to the highest current density.

### DETERMINATION OF MOBILITY OF POSITIVE IONS

The theoretical formula may also be used to determine values of mobility of the positive ions, $U$, of the gas in the discharge tube.

Using the measured values of $r_0$ and $V_0$, the measured potential, $V$, of one other equipotential surface, near the cathode glow, but not directly at the edge of the cathode glow, and the current $I_1$, and solving the equation for the value of $U$, we can obtain the value of the mobility for each current density.

TABLE II

*Aluminium Wire Cathode*

Diam., 3.2 mm.; exposed length, 3.2 cm.; Helium pressure = 1.55 mm.

| Dist. | $I_1 = .625 \times 10^{-3}$ Amp. | | $I_1 = .94 \times 10^{-3}$ Amp. | | $I_1 = 1.25 \times 10^{-3}$ Amp. | | $I_1 = 1.56 \times 10^{-3}$ Amp. | |
|---|---|---|---|---|---|---|---|---|
| ($r$) | $V$ | | $V$ | | $V$ | | $V$ | |
| Cm. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. |
| .18.... | 151.7 | 150.3 | 179.0 | 179.7 | 203.0 | 206.7 | 222.5 | 226.3 |
| .20.... | 178.0 | 176.6 | 208.5 | 207.2 | 236.8 | 232.7 | 259.8 | 255.2 |
| .22.... | 199.2 | 200.3 | 233.0 | 232.7 | 258.5 | 255.6 | 280.3 | 279.1 |
| .24.... | 218.5 | 219.7 | 251.5 | 253.4 | 274.6 | 276.4 | 296.2 | 299.2 |
| .25.... | 226.2 | 228.6 | | | | | | |
| .26.... | ..... | ..... | 274.0 | 272.3 | 298.3 | 294.3 | 318.4 | 317.2 |
| .27.... | 244.5 | 245.8 | ..... | ..... | ..... | ..... | | |
| .28.... | ..... | ..... | 289.9 | 288.3 | 321.8 | 308.8 | 339.8 | 333.5 |
| .29.... | 256.2 | 260.2 | | | | | | |
| .30.... | ..... | ..... | 304.7 | 303.1 | 322.0 | 321.6 | 355.8 | 346.4 |
| .31.... | 267.3 | 273.1 | | | | | | |
| .32.... | 273.5 | 278.6 | 314.2 | 314.1 | 332.2 | 332.7 | 362.5 | 357.6 |
| .34.... | 285.0 | 287.6 | 322.5 | 323.8 | 339.8 | 340.7 | 367.7 | 366.3 |
| .36.... | 292.5 | 295.2 | 330.0 | 330.2 | 343.5 | 347.4 | 373.2 | 372.2 |
| .375 ... | ..... | ..... | ..... | ..... | ..... | ..... | 374.5 | 374.5 |
| .38.... | 298.0 | 299.4 | 334.8 | 335.5 | 350.5 | 350.5 | | |
| .386 ... | ..... | ..... | 336.0 | 336.0 | | | | |
| .39.... | 300.8 | 300.8 | | | | | | |
| U..... | $2.01 \times 10^3$ | | $2.68 \times 10^3$ | | $3.84 \times 10^3$ | | $4.17 \times 10^3$ | |
| $U_1$..... | $3.11 \times 10^3$ | | $4.15 \times 10^3$ | | $5.95 \times 10^3$ | | $6.46 \times 10^3$ | |

When the mobilities are thus computed the values obtained at the different current densities are not found to be in agreement as might be expected from the theory, but the value of the mobility obtained increases as the current density is increased. The suggestion occurs that this may be due to the nitrogen present as an impurity. Since the ionization potential of nitrogen is lower than that of helium, it might be expected that at the lower currents the

nitrogen ions would carry a relatively higher proportion of the current, and as the current is increased the more mobile helium ions carry a larger percentage of the current, thus giving higher average mobility. Spectroscopic examination of the glow tends to support this explanation, since the helium lines become relatively much more intense as the current density is increased.

The law that the product of the mobility times the pressure is constant is found to hold at higher gas pressures. In order to compare mobilities obtained at different pressures, the value, $U_1$, of the mobility at 1 mm. pressure was computed for each case on the basis of the above law. The values of $U_1$ in the two tables

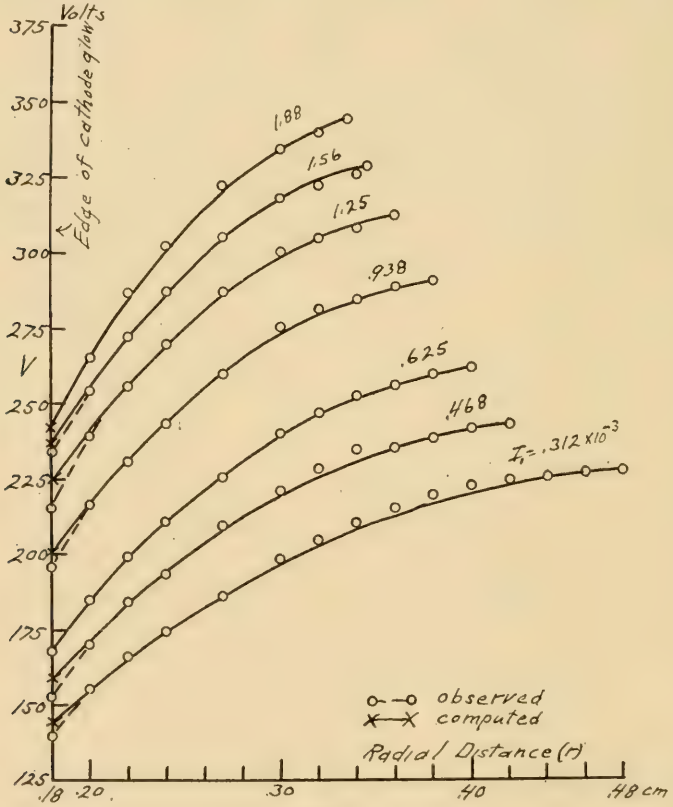


FIG. 6

do not agree. All, except one, are higher than the mobility of helium, $3.9 \times 10^3$, computed from measurements of Franck and Pohl made at atmospheric pressure,[15] the highest value obtained being approximately five times as high as their value.

*Argon.*—The argon used was from a bulb obtained from the Linde Gas Products Company and contained a trace of nitrogen as an impurity. The argon was introduced into the discharge tube without any further purification except drying—the tube being "washed out" by repeated fillings and evacuation. The results are incorporated in Tables III, IV, and V, and are shown graphically in Figs. 6, 7, 8.

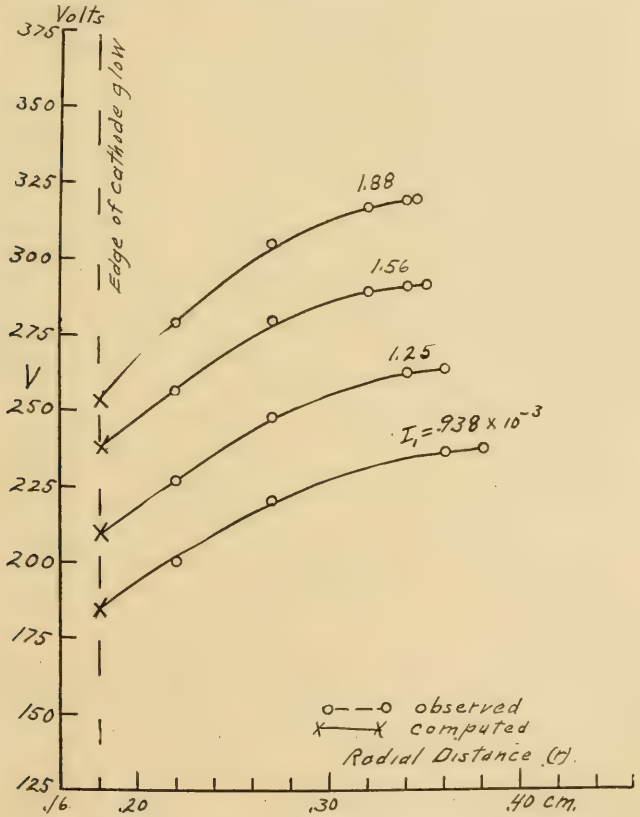


FIG. 7

[15] Franck & Pohl, *Verh. d. D. Phys. Ges.*, 9, p. 194, 1907.

The results in Table III were taken immediately after filling the apparatus from the argon bulb. They show an excellent agreement between the observed and calculated potentials, sub-

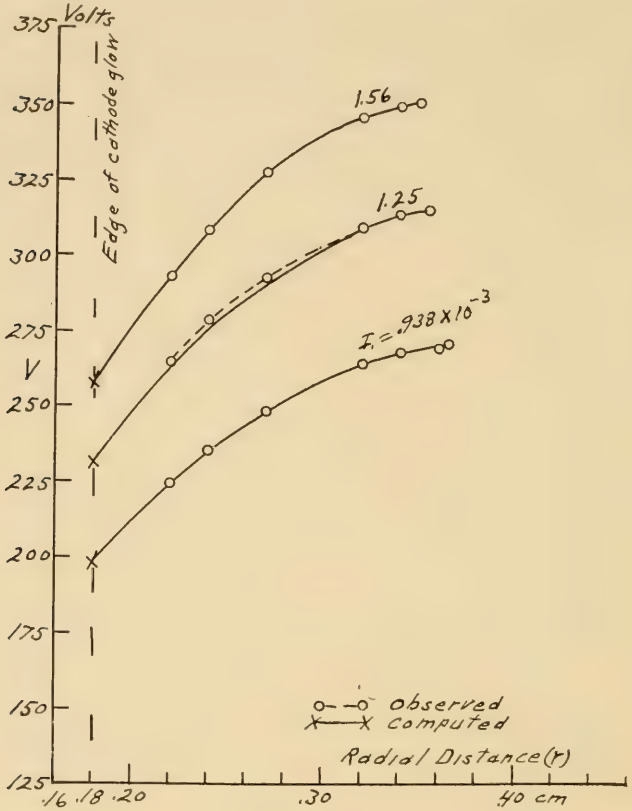


FIG. 8

stantiating the theory very satisfactorily. None of the values could be considered unsatisfactory except one or two at the distance .18 cm., the edge of the polarization region, where the observed values of the potential are markedly lower than the computed values. As explained previously, this is believed to be due to the setting of the probe slightly too close to the cathode.

The values of the mobility computed from these data are in fair

TABLE III

*Aluminium Wire Cathode*

Diam., 3.2 mm.; exposed length, 3.2 cm.; Argon, pressure = .75 mm.

| Dist. | $I_1 = .312 \times 10^{-3}$ Amp.* | | $I_1 = .468 \times 10^{-3}$ Amp. | | $I_1 = .625 \times 10^{-3}$ Amp. | | $I_1 = .938 \times 10^{-3}$ Amp. | | $I_1 = 1.25 \times 10^{-3}$ Amp. | | $I_1 = 1.56 \times 10^{-3}$ Amp. | | $I_1 = 1.88 \times 10^{-3}$ Amp. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $(r)$ | $V$ | | $V$ | | $V$ | | $V$ | | $V$ | | $V$ | | $V$ | |
| Cm. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. |
| .18 | 140.8 | 143.7 | 152.5 | 158.2 | 167.7 | 168.3 | 195.6 | 199.2 | 215.3 | 223.7 | 228.0 | 236.4 | 234.0 | 241.7 |
| .20 | 155.2 | 155.2 | 170.2 | 172.2 | 184.9 | 184.5 | 216.5 | 216.5 | 239.0 | 241.4 | 254.0 | 255.6 | 265.5 | 265.5 |
| .22 | 166.1 | 165.0 | 184.0 | 183.8 | 199.0 | 198.5 | 230.5 | 230.7 | 255.6 | 256.2 | 272.2 | 272.7 | 286.6 | 284.4 |
| .24 | 174.3 | 173.0 | 193.3 | 194.2 | 210.5 | 210.3 | 243.2 | 243.6 | 269.3 | 269.6 | 287.0 | 287.3 | 302.0 | 301.4 |
| .27 | 186.0 | 186.0 | 209.4 | 208.4 | 225.9 | 226.1 | 259.5 | 259.4 | 286.6 | 285.7 | 305.2 | 304.6 | 322.5 | 321.5 |
| .30 | 198.3 | 196.2 | 221.1 | 218.6 | 240.2 | 238.9 | 275.0 | 272.4 | 300.0 | 298.3 | 317.7 | 317.6 | 334.0 | 335.2 |
| .32 | 204.5 | 202.0 | 228.2 | 225.3 | 247.2 | 245.8 | 281.0 | 279.4 | 304.0 | 304.6 | 322.2 | 324.6 | 339.8 | 341.4 |
| .335 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 344.0 | 344.0 |
| .34 | 210.0 | 207.2 | 234.5 | 230.3 | 252.3 | 251.8 | 284.3 | 284.1 | 307.8 | 310.2 | 326.0 | 327.5 | | |
| .345 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 328.5 | 328.5 | | |
| .36 | 215.2 | 212.1 | 235.3 | 235.1 | 256.0 | 256.4 | 288.5 | 288.4 | 311.7 | 311.7 | | | | |
| .38 | 219.4 | 216.5 | 238.4 | 239.5 | 259.2 | 260.0 | 290.5 | 290.5 | | | | | | |
| .40 | 222.4 | 219.9 | 241.5 | 241.5 | 261.7 | 261.7 | | | | | | | | |
| .42 | 224.3 | 223.0 | 243.0 | 243.0 | | | | | | | | | | |
| .44 | 226.0 | 225.5 | | | | | | | | | | | | |
| .46 | 227.2 | 227.2 | | | | | | | | | | | | |
| .48 | 228.0 | 228.0 | | | | | | | | | | | | |
| $U$ | $9.13 \times 10^3$ | | $7.10 \times 10^3$ | | $6.07 \times 10^3$ | | $7.16 \times 10^3$ | | $7.52 \times 10^3$ | | $5.92 \times 10^3$ | | $5.56 \times 10^3$ | |
| $U_1$ | $6.85 \times 10^3$ | | $5.33 \times 10^3$ | | $4.55 \times 10^3$ | | $5.37 \times 10^3$ | | $5.64 \times 10^3$ | | $4.44 \times 10^3$ | | $4.17 \times 10^3$ | |

Average value of $U_1 = 5.19 \times 10^3$.

agreement and do not show the marked variations with change of current density that was found with helium. However, the actual values of mobility are found to be about five times as large as the value,[16] $1.04 \times 10^3$, obtained by computation from Franck's measurements made at atmospheric pressure.

TABLE IV

*Aluminium Wire Cathode*

Diam., 3.2 mm.; exposed length, 3.2 cm.; Argon, pressure = .75 mm.

| Dist. | $I_1 = .938 \times 10^{-3}$ Amp. | | $I_1 = 1.25 \times 10^{-3}$ Amp. | | $I_1 = 1.56 \times 10^{-3}$ Amp. | | $I_1 = 1.88 \times 10^{-3}$ Amp. | |
|---|---|---|---|---|---|---|---|---|
| $(r)$ | $V$ | | $V$ | | $V$ | | $V$ | |
| Cm. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. |
| .18.... | ..... | 183.6 | ..... | 208.4 | ..... | 235.8 | | 251.8 |
| .22.... | 200.5 | 201.9 | 226.5 | 227.8 | 255.7 | 256.8 | 277.7 | 277.9 |
| .27.... | 219.5 | 218.8 | 246.8 | 246.3 | 278.0 | 275.6 | 303.0 | 301.2 |
| .32.... | ..... | ..... | ..... | ..... | 288.0 | 287.7 | 315.4 | 315.4 |
| .34.... | ..... | ..... | 260.6 | 260.8 | 290.0 | 290.0 | 318.0 | 318.0 |
| .345... | ..... | ..... | ..... | ..... | ..... | ..... | 318.2 | 318.2 |
| .35.... | ..... | ..... | ..... | ..... | 290.6 | 290.6 | | |
| .36.... | 236.0 | 235.8 | 262.2 | 262.2 | | | | |
| .38.... | 237.0 | 237.0 | | | | | | |
| U..... | $21.0 \times 10^3$ | | $20.0 \times 10^3$ | | $20.5 \times 10^3$ | | $15.4 \times 10^3$ | |
| $U_1$..... | $15.75 \times 10^3$ | | $15.00 \times 10^3$ | | $15.35 \times 10^3$ | | $11.55 \times 10^3$ | |

The values shown in Table IV and Fig. 7 were taken with the same sample of gas as the readings of Table III, but after it had been standing in the apparatus several days. The computed and observed potentials are in good agreement, but markedly lower than the values found in Table III. This was not surprising, since it is a well-recognized fact that a slight change in the cathode surface may produce a marked change in the total potential fall, but this does not involve any change in the potential gradient in the Crooke's dark space, nor would it have any influence on the values of the mobility in that region. A comparison of Figs. 6 and 7 shows that the curves of Fig. 7 are flatter than those in Fig. 6, the drop of potential through the Crooke's dark space being

[16] J. Franck, *Ber. d. D. Phys. Ges.*, 8, p. 291, 1910.

smaller than with the fresh filling. The comparison of the mobilities in the two cases shows that the mobility has been increased to a remarkable degree by allowing the gas to stand in the apparatus.

To make certain that this increase in mobility was not accidental the system was thoroughly evacuated, washed out with fresh argon

TABLE V

*Aluminium Wire Cathode*

Diam., 3.2 mm.; exposed length, 3.2 cm.; Argon, pressure = .75 mm.

| Dist. | $I_1 = .938 \times 10^{-3}$ Amp. | | $I_1 = 1.25 \times 10^{-3}$ Amp. | | $I_1 = 1.56 \times 10^{-3}$ Amp. | | |
|---|---|---|---|---|---|---|---|
| (*r*) | *V* | | *V* | | *V* | | |
| Cm. | Obs. | Calc. | Obs. | Calc. | Obs. | Calc. | |
| .18..... | ..... | 198.1 | ..... | 231.3 | ..... | 257.7 | |
| .22..... | 224.2 | 224.3 | 264.5 | 262.8 | 292.5 | 293.2 | |
| .24..... | 235.2 | 235.1 | 278.5 | 275.6 | 308.0 | 307.9 | |
| .27..... | 248.3 | 248.2 | 292.0 | 290.4 | 327.4 | 325.1 | |
| .32..... | 264.0 | 263.9 | 309.0 | 309.2 | 345.5 | 345.5 | |
| .34..... | 268.0 | 268.0 | 313.4 | 313.2 | 349.0 | 349.6 | |
| .35..... | ..... | ..... | ..... | ..... | 350.5 | 350.5 | |
| .355..... | ..... | ..... | 314.8 | 314.8 | | | |
| .36..... | 269.7 | 270.2 | | | | | |
| .365..... | 270.7 | 270.7 | | | | | Average |
| U..... | $8.92 \times 10^3$ | | $7.72 \times 10^3$ | | $7.12 \times 10^3$ | | |
| $U_1$..... | $6.69 \times 10^3$ | | $5.79 \times 10^3$ | | $5.34 \times 10^3$ | | $5.94 \times 10^3$ |

from the bulb to remove, as far as possible, the impurities from the apparatus, and refilled with fresh argon at the same pressure—.75 mm. A set of readings were taken immediately and are given in Table V, with a graphical representation in Fig. 8. The curves show nearly the same form as the curves of Fig. 6. The mobilities show a reasonable agreement with the mobilities found in Table III.

The gas was then allowed to stand for several days and another series of readings were taken. These gave values of *U* practically identical with those found in Table IV, showing that the mobility increases if the gas is allowed to stand in the apparatus. If this increase were caused by impurities, as is believed, the impurities must originate in the apparatus and be relatively minute in volume,

for in no case was there any change in the pressure as read on the McLeod gauge which could detect a change of about five-tenths of one per cent.

If this is true, the value of the mobility must be very sensitive to impurities in the gas, since they would be given up very slowly, and the values found for the gas after a fresh filling may be higher than the true value of $U$ for argon, since it is not strictly pure. Franck[17] found that the negative ion was very sensitive to impurities, but he did not find that impurities seemed to show any influence on the mobility of the positive ions. However, measurements made by this method might well be more sensitive to the effect of impurities—at least to the presence of hydrogen if Skinner's[18] value for the mobility of hydrogen is correct—than measurements made by the ordinary methods.

## SUMMARY

It has been shown that in the negative glow there are equal positive and negative currents. Assuming, then, that the negative glow is the source of positive ions, and that the negative ions originate from the extremely small electron current caused by the bombardment of the cathode by the positive ions, it has been shown that at a distance of one ionizing interval toward the cathode from the negative glow the positive ions carry three-fourths of the current, at the distance of two intervals seven-eighths, and so on, so that at a comparatively short distance the positive ions carry practically all the current.

From this assumption a theory has been developed for the potential at any point in the gas between the point of minimum gradient and the polarization region for wire cathodes.

This theory is tested for an aluminium cathode in the monatomic gases, helium and argon, and is found to correspond very satisfactorily with the experimental results.

The values for the mobility in helium, which was not entirely pure, computed from the theoretical equation (8), were not constant for different current densities, and the values of the mobility

[17] J. Franck, *Ber. d. D. Phys. Ges.*, 8, p. 291, 1910.
[18] C. A. Skinner, *Phys. Rev.*, XII, p. 143, 1918.

at 1 mm. pressure, $U_1$, did not agree when computed from the two pressures used.

Two fresh fillings of argon gave mobilities which checked quite well and there was not any decided variation in the mobility when the current density was changed. However, the mobility is about five times as large as the value found by Franck with measurements made at atmospheric pressure and increased by three or four times its original value if the gas was allowed to stand in the apparatus for several days. This makes it extremely doubtful whether the value of mobility obtained is the value that would be found if the argon were pure when the first measurements were made.

If the value found is larger than would be found for pure argon, then this is a reliable method for measuring mobilities, and Skinner's suggestion that in the case of hydrogen the high mobility which he found—about twelve times as high as the values which ordinary methods of measurements give—is due to an atomic ion would be supported. This can be determined only by using pure argon, which the writer was unable to secure for the purpose of the present investigation, but hopes to be able to obtain for later work.

However, if the pure monatomic gases give abnormally high mobilities, it seems probable that the form in which the mobility factor enters the theoretical formula must need be modified, presumably by the introduction of another constant factor.

# THE DIATOMS (BACILLARIOIDEAE) OF NEBRASKA

BY CLARENCE J. ELMORE

## OCCURRENCE

Diatoms are found practically in all places where there is water—in lakes, rivers, creeks, ponds, tubs, troughs, tanks; and on damp ground, rocks, walls, or boards. All water, from the ocean to the smallest puddle caused by the tracks of cattle's feet, provided the puddles persist for a few days, is almost certain to contain diatoms. When unmixed with other substances they present a brownish color. Often the entire bottom of a stream may be covered to a thickness of an inch or more with a brown mass of diatoms. But the greater number occur mixed with other algae, in which case their brown color is hidden by the green of the algae.

Diatoms are also found in the fossil state. In this condition they are called Diatomite by geologists, or Kieselguhr in commerce. The name Infusorial Earth has also been applied to them, but this is incorrect, for diatoms are not Infusoria.

Diatoms differ from other plants in that their cell walls are thoroughly infiltrated with silica, or quartz of the opal variety. The form of the cell is often likened to a pill box or a telescope, one-half fitting over the other. The statement made in practically all of the textbooks is that when a cell divides the two valves, ends of the cell, separate slightly and a new valve grows inside of each, thus forming two new cells. Thus each new cell has one of the original valves of the mother cell and a new valve formed inside of the girdle of the old one. Hence it would appear that one of the new cells is the exact size of the mother cell and the other slightly smaller, the reduction in size going on with each cell division. This process continues until a certain minimum size is reached, when an auxospore is formed. The necessity for auxospore formation arises from the fact that the cell walls of diatoms are silicified and so can not grow, together with the fact that they become smaller with each division.

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The simplest manner of auxospore formation is by the protoplasmic contents of a cell escaping from its siliceous shell and growing to the normal size for the species and then secreting a new shell about itself. Or in some cases two cells are formed in this way from a single mother cell. Another method is for the contents of two cells to escape and conjugate, forming in some cases one, and in other cases two, auxospores.

Since diatoms multiply with great rapidity, the diminution in size ought to require the very frequent formation of auxospores. But the actual condition is that they are of comparatively rare occurrence. The discrepancy arises from the fact that the foregoing description of a diatom is only partly true. In some cases the girdle of the old valve inside of which the new valve is formed enlarges so that the new valve is as large as, or larger than, the old one. In *Lysigonium* (*Melosira*), a genus in which the cells adhere together, long filaments are formed which are practically uniform in size. Otto Müller, *Die Zellhaut und das Gesetz der Zellteilungs folge von Meloseira arenaria Moore,* has shown that in this species the girdle is enlarged according to a regular law, so that the minimum size is very seldom reached. And according to this law only one auxospore is formed, where, if the diminution in size took place regularly, 1,052,100,000,000 would be formed. This easily accounts for the infrequent occurrence of auxospores in this species.

In *Fragilaria*, another genus in which the cells adhere in bands, the girdles can be seen meeting, but not overlapping, and in this genus, too, there is no apparent diminution in size of the filaments.

Diatomite, when pure, is a white or grayish substance so light that it floats on water. It is often mixed with other substances. In Nebraska it usually contains more or less calcium carbonate, the amount varying from a slight trace to so much that it becomes a hard limestone with comparatively few diatoms. The deposit from Greeley County, however, is practically pure. In our region, at least, it is not often mixed with other substances than calcium carbonate. Conditions favorable to the growth of diatoms were favorable to the growth of the organisms producing the carbonate, and conditions under which inorganic sediment was formed were

unfavorable to the growth of diatoms. It is likely, however, that some diatoms were growing when inorganic sediment was being formed, but in the large amount of this sediment they have been overlooked.

## COLLECTING AND PRESERVING

Few directions are needed for collecting diatoms. Any vegetable growth in water or in damp places is likely to contain them. All that is necessary is to get the material in any way that is most convenient and to carry it in whatever may be at hand for the purpose.

When it is desired to preserve the protoplasmic contents of diatom cells, they may be placed in formaldehyde or other preservative in the same manner as other algae. For careful cytological work they may be killed in hot mercuric bichloride solution, and then, after washing and dehydrating, mounted in balsam.

The determination of species depends mostly on the siliceous shells and when they are collected for that purpose no preservative need be used. The material containing them may be wrapped in paper and allowed to dry. Diatoms preserved in this way are in no way inferior to those preserved by more careful methods for purposes of identification when it is only the shells that are to be examined.

## MOUNTING

The markings on the shells are often very delicate and difficult to see. In many of the smaller species they can not be seen when in their natural condition and mounted in water. They are more easily seen when the protoplasm is removed from the shells. This may be removed by boiling in a test tube in nitric acid. This destroys the cell contents, leaving only the siliceous shells. Water is then added, and after the diatoms have settled it is poured off. This process is repeated until the acid is all removed. A drop of the liquid containing them is placed on a coverglass and allowed to dry.

The method usually used by the writer, however, is to dry a small portion of the material containing the diatoms on a coverglass and to heat until all of the organic material has been burned

out. By this method they may be prepared much more quickly than by treating with acid. When there is sufficient heat, as with a gas flame, the coverglass may be laid on a flat piece of iron (the writer has used the blade of an old table knife) and held in the flame. When first heated the material turns black. It should be heated until the blackness disappears. If the heat of the flame is not sufficient, as is likely to be the case with an alcohol lamp, it may be increased by the use of a blowpipe. If the coverglass is held on a piece of silver, it will heat much more readily, owing to the greater conductivity of the silver. For this purpose the writer has used an old silver quarter dollar with a hole in it, a wire being fixed in the hole for a handle. In using a blowpipe the flame should be directed on the under side of the metal on which the coverglass is lying and not directly on the coverglass.

Nearly all of the fossil diatoms found in Nebraska are mixed with limestone or some form of calcium carbonate. This must be removed, for there is often so much of it that the diatoms are hidden entirely. This may be done by treating with hydrochloric acid. The method is the same as that for using nitric acid except that it is not necessary to heat it.

When dried on the coverglass they may be mounted in Canada balsam, but the markings are seen much more easily if mounted in styrax.[1]

[1] Styrax can be procured only in the crude state and must be prepared for use. The first step in preparing it is to spread a thin coating of it on a pane of glass or a plate and allow it to dry until all of the water has been removed. It is then dissolved in a mixture of equal parts of benzine and alcohol, or sulphuric ether and absolute alcohol. The solution is then filtered through filter paper. If it is so thick that it will not pass through the filter paper readily, more of the alcohol and ether may be added. After filtering it is ready for use. A quantity may be made up at one time since it will keep indefinitely. A drop of the styrax is placed on the coverglass containing the diatoms. If it becomes opaque at first it must be allowed to stand until it becomes clear. This may require several hours. This clearing may be hastened by heating gently. When cleared it is placed on a slide. The slide should then be heated until the volatile portion of the styrax solution is driven off. This will cause bubbles under the coverglass and the heating should be continued until the bubbles cease to form. When cooled the bubbles will disappear.

The location of individual diatoms on the slide may be indicated by drawing a circle around each specimen on the coverglass. Sanford's Indelible Stamping ink has been found satisfactory for this purpose. It may be applied with a pen and does not run on the glass. When dry it is not much affected by the oil of an oil immersion objective. If there are several specimens marked on one slide, a diagram of the location of each may be drawn on the label, indicating each species by a number.

## RELATIONSHIP

The systematic place of diatoms is a matter about which there has been much disagreement. They were formerly regarded as animals and placed among the Infusoria. They are now universally regarded as plants, but there seems to be no general agreement as to their relationship. The placing them among the Brown Algae was based merely on their color, which is probably only an accidental or perhaps a physiological resemblance and has no systematic significance. That they are a derived and not a primitive group is indicated by the fact that they appeared comparatively late in geological time, none being known earlier than the Devonian. And since their appearance very little change has taken place. It is possible that they have evolved through earlier periods without their siliceous cell walls, and suddenly, as if by mutation, their walls became silicified. Hence all of their earlier history is lost, and at their first appearance in geological time they had reached their present form.

Forms like *Lysigonium* (*Meloseira*) seem closely related to the unsilicified filamentous algae and are probably derived from them. And the round diatoms in which the cells are separate may be considered as the cells of a filament which have become separated.

In the filamentous diatoms that form ribbon-like bands, instead of cylindrical filaments we have the same structure except that the filaments have become flattened. And the single-celled long (flat) diatoms may be considered as the cells of such a filament broken apart.

Whatever views various botanists have as to the relationships of diatoms, they are nearly all agreed that diatoms and desmids are

closely related. By their mode of forming zygospores, desmids are closely related to the filamentous *Conjugatae, e.g., Spirogyra.* And some diatoms in their formation of auxospores have a form of conjugation very similar to that of desmids. For this reason it seems best to place both diatoms and desmids with the filamentous *Conjugatae* under the phylum *Zygophyceae,* making of the unsilicified groups a separate class and of the siliceous ones a class of equal rank, the *Bacillarioideae.*

## THE USE OF THE TERM VARIETY

Diatoms vary so greatly in size and form between one auxospore stage and the next that the early collectors who based their species on size and form alone described as species many conditions that are mere stages in the life history of a single species. The size necessarily decreases with each cell division until an auxospore is formed, except in those genera whose valves do not overlap, because each new valve is formed inside of an old one. If one part of the girdle is thicker than the rest, the new valve formed inside this valve will be slightly constricted at this point; and this constricting process will continue, making the constriction deeper and deeper with each division until the next auxospore stage is reached. If the thickening is at the ends, the valves will grow proportionally shorter with each division. So some species occur in many conditions that have been described as distinct species. The earlier works recognized few varieties, making a separate species for each condition in which a species was found. Later writers have brought together many of these so-called species and called them varieties, or in some cases, forms. But the term variety can scarcely be applied to diatoms. The species of diatoms present the same varieties now that they did in Tertiary times; so if these varieties are thus fixed, they are not varieties, but species. And those that merely represent conditions between two auxospore stages are not entitled to a separate name any more than an oak tree two feet high deserves a name separate from the name given to an older tree of the same species.

It is only by a most thorough and careful study of any species that all of the forms in which it may appear can be determined.

This work has been done for very few species. Hence the assigning of any form to a place as a species or that of a mere form has been and still is a matter mainly of individual judgment, in very few cases supported by sufficient data.

For these reasons the term variety has been discarded in the present work except as it has been necessary to use it in referring to other descriptions. It is probable that future work will greatly reduce the number of species of diatoms.

## DESCRIPTIONS AND DRAWINGS

Many of the descriptions have been adapted from other works, but in all cases so modified as to include any peculiarities found in our local forms. The drawings are all original except that of *Chaetoceros elmorei,* this one being taken from the drawing accompanying the original description by Professor C. S. Boyer. The drawings are of actual specimens and in no case has an attempt been made to represent generalized or typical forms. In diatoms the same species occurs in many forms, hence the large number of figures given for some species.

All of the localities where each species has been found are given. This forms a fair measure of the frequency of occurrence of any species.

The writer wishes to express his indebtedness to the late Professor C. E. Bessey and Professor E. H. Barbour, of the University of Nebraska, for advice and assistance in the work throughout; also to Professor C. S. Boyer, of Philadelphia, for the identification of several species as well as for many valuable suggestions. The work of Mrs. Eleanor Barbour Cook on a particularly rich deposit of diatomite at Agate, Nebraska, has been incorporated into this work, all of the species reported from Agate being from this collection and from one sent by Mr. Harold J. Cook.

The fossil material from Greeley County was collected in 1887 by Mr. Russell and given to Professor Bessey, who furnished it to the writer. That from other localities was furnished by Professor Barbour, some of it having been collected by Mr. A. C. Whitford, that from Thedford by Mr. J. N. Neely and Mr. J. M.

McMillan, and that from Merriman by Mr. L. E. Fagan. The collection from Loup City was furnished by Mr. Clarence O. Peterson, and that from Hay Springs by Prof. R. W. Ellis.

Much of the recent material has been collected by friends of the writer, among whom are: Prof. W. E. Allen, Fresno and Stockton, Calif.; Rev. J. M. Bates, Atkinson, Ewing, Long Pine, and Red Cloud; Prof. A. T. Bell, Crete; Prof. C. E. Bessey, Ashland; Miss Grace Bradburn (Mrs. Chas. Frisch), Broken Bow; Miss Pearl Chase, Ainsworth; Prof. F. E. Clements, Holt County; Miss Alba Cosner, New Helena; Miss Harriet Ege, Rosebud, S. Dak.; Miss Cora Elmore (Mrs. C. H. Bancroft), Talmage; Mr. Wm. Fleming, Cheyenne, Wyo.; Prof. J. H. Flodman, Wahoo; Miss Ethel Hansen, Grand Island; Mr. W. J. Hesser, Plattsmouth; Miss Isabel Johnston, Lodi; Mr. Ray Kellenbarger, Anselmo; Mr. E. F. Lange, Fairbury; Mr. Ray McCann, Estes Park, Colorado; Mr. Theodore Moline, Polk; Prof. A. K. Peiterson, Weeping Water; Prof. N. F. Petersen, many places in eastern Nebraska; Prof. Roscoe Pound, Sheridan County, Cherry County; Prof. J. H. Powers, Colorado; Prof. A. A. Reed, Crete; Mr. J. A. Reed, Blue Springs; Mrs. Perry Robbins, New Helena; Mr. Windom Rosene, Stromsburg; Prof. DeAlton Saunders, Bellevue; Miss Laura Sutherland, Chippewa Falls, Wis.; Miss Lilian Sutherland, Pawnee City; Miss Fae Troyer (Mrs. Wm. Fleming), Turtle River and Dallas, S. Dak.; Prof. J. E. Weaver, Crete; A. C. Whitford, Dismal River and many other places in the Sand Hills; Prof. Elda R. Walker, lakes in Sand Hills; Prof. R. T. Young, Devils Lake, N. Dak. Besides these much material from the vicinity of Grand Island has been furnished by members of the writer's own family.

### Artificial Key to the Genera

*A.* Valves round.

*b.* Cells without horns (Fam. *Coscinodiscaceae*).

*c.* Cells united in filaments. 1. *Lysigonium,* page 36.

*cc.* Cells single.

*d.* With distinct central and marginal portions. 2. *Cyclotella,* page 39.

*dd.* Central and marginal portions grading into one another.

*e.* With marginal spines. 3. *Stephanodiscus,* page 40.

*ee.* Without marginal spines.
4. *Coscinodiscus,* page 41.
*bb.* Cells with horns (Fam. *Chaetocerataceae*).
5. *Chaetoceros,* page 42.
*bbb.* Cells with short processes. 6. *Biddulphia,* page 43.
*AA.* Valves linear, elliptical, oval, or sometimes irregular.
*b.* Valves with a pseudoraphe, *i.e.,* a clear longitudinal strip.
*c.* Cells in girdle view rectangular, nearly as broad as long (Fam. *Tabellariaceae*).
*d.* Transverse ribs of the valves when present not extending into the cell cavity.
*e.* Valves with a few heavy ribs.
7. *Tetracyclus,* page 44.
*ee.* Valves with striations, no ribs.
8. *Striatella,* page 45.
*dd.* Ribs seen in girdle view to extend deeply into the cell.
9. *Denticula,* page 46.
*cc.* Cells elongated in both valve and girdle view.
*d.* Cells wedge-shaped in girdle view (Fam. *Meridionaceae*).
*e.* Without transverse ribs.
10. *Sceptroneis,* page 47.
*ee.* With transverse ribs.
11. *Meridion,* page 48.
*dd.* Cells rectangular in girdle view, or if of other form, the rachis not median (Fam. *Fragilariaceae*).
*e.* Rachis median.
*f.* Valves with heavy ribs.
12. *Odontidium,* page 49.
*ff.* Valves with striations, no ribs.
*g.* Cells short; in filaments.
13. *Fragilaria,* page 51.
*gg.* Cells longer, forming fan-like stalked clusters.
14. *Synedra,* page 53.
*ggg.* Cells symmetrical, in radiating clusters.
15. *Asterionella,* page 57.
*ee.* Rachis near one margin.
*f.* Rachis nearly on ventral margin, not interrupting the striations. 16. *Eunotia,* page 57.
*ff.* Rachis somewhat removed from the ventral margin, interrupting the striations.
17. *Ceratoneis,* page 60.
*bb.* One or both valves with a raphe; cells usually elongated.
*c.* Rachis median or nearly so; valves not keeled (Fam. *Naviculaceae*).

*d.* Cells rectangular in girdle view.
*e.* Cells with striations and a row of transverse septa around the margins.
18. *Mastigloia,* page 61.
*ee.* Cells with striations but no septa.
*f.* Valves not keeled.
*g.* Raphe straight or nearly so.
*h.* No heavy lines bordering the raphe.
*i.* Cells straight in girdle view.
*j.* Central nodule round.
*k.* Face of valves flat; raphe straight.
19. *Navicula,* page 62.
*kk.* Face of valves convex; raphe slightly sigmoid.
20. *Scoliopleura,* page 94.
*jj.* Central nodule elongated transversely forming a stauros.
21. *Stauroneis,* page 95.
*jjj.* Central nodule elongated longitudinally into 4 horns.
22. *Diploneis,* page 97.
*ii.* Cells curved in girdle view; only one valve with a raphe.
*j.* Cells elongated.
23. *Achnanthes,* page 98.
*jj.* Cells nearly circular.
24. *Cocconeis,* page 100.
*hh.* Raphe bordered by two heavy lines giving the appearance of a double raphe.
25. *Brebissonia,* page 103.
*gg.* Raphe sigmoid.
26. *Gyrosigma,* page 104.
*ff.* Valves keeled. 27. *Amphiprora,* page 107.
*dd.* Cells wedge-shaped both in girdle and valve view.
*e.* Cells straight in girdle view.
28. *Gomphonema,* page 107.
*ee.* Cells curved in girdle view.
29. *Rhoicosphenia,* page 114.
*ddd.* Raphe arcuate; cells more or less moon-shaped.
*e.* Valves without transverse ribs.
*f.* Raphe and central nodules not close to the margins of the valves.

*g.* Terminal nodules near the ends, raphe more or less curved.

30. *Cymbella,* page 115.

*gg.* Terminal nodules usually distant from the ends, raphe straight.

31. *Encyonema,* page 122.

*ff.* Raphe and central nodule close to the ventral margin.

32. *Amphora,* page 124.

*ee.* Valves with transverse ribs; raphe not evident.

33. *Cystopleura,* page 125.

*cc.* Cells usually elongated; rachis usually on the margin of the valve, so that striations are not interrupted by it; valves with a dotted keel (Fam. *Bacillariaceae*).

34. *Homoeocladia,* page 130.

*ccc.* Cells usually oval or elliptical, seldom elongated; with two wings (Fam. *Surirellaceae*).

*d.* Valve surface undulate. 35. *Sphinctocystis,* page 145.

*dd.* Valve surface not undulate.

*e.* Valves cuneate, reniform, elliptical, or linear.

36. *Surirella,* page 147.

*ee.* Valves nearly circular, bent into saddle shape.

37. *Campylodiscus,* page 150.

## Class Bacillarioideae

One-celled aquatic plants living in filaments, or more commonly broken into single cells; free, attached to the substratum, epiphytic on other plants, or enclosed in gelatinous tubes; cell wall of cellulose infiltrated with silica; the wall of each cell (frustule) consisting of two plates (valves) which form the ends of the cell and are connected by two or more girdles, the one fitting outside the other like the cover of a box. Protoplasm parietal and forming a large mass in the center of the cell in which the nucleus is located and which separates the central vacuole into two parts. Chromatophores plate-like or granular; chlorophyll obscured by a brownish coloring matter, phycoxanthin. In the elongated, free-swimming families, *Naviculaceae, Bacillariaceae,* and *Surirellaceae,* there is a longitudinal slit (raphe) which in *Naviculaceae* is median, or nearly so, and in the other families is lateral. Propagation by cell division in which each daughter cell retains one of the valves of the mother cell. Reproduction by the sexual or asexual formation of auxospores.

SYSTEMATIC KEY TO THE FAMILIES AND GENERA

*A.* Order *Eupodiscales.* Round Diatoms. Cells in cross section usually circular, less commonly polygonal, elliptical, and rarely irregular; valves marked concentrically or radially by dots, areolations, lines, or ribs; cells often with spines, processes, or horns.

*b.* Cells without horns. Family 1. *Coscinodiscaceae,* page 36.

*bb.* Cells with long horns or bristles. Family 2. *Chaetocerotaceae,* page 42.

*bbb.* Cells with shorter spines or processes. Family 3. *Biddulphiaceae,* page 43.

*AA.* Order *Naviculales.* Flat Diatoms. Filaments flattened, usually fragmented into single cells; cells narrowly elliptical to linear, less commonly broadly elliptical, lunate, cuneate, or irregular; valves marked pinnately or transversely by dots, areolations, lines, or ribs; cells (in our species) without spines, processes, or horns.

*b.* Rachis of the valves (*i.e.,* the line between the divergent pinnate markings) evident as a narrow, unmarked strip (pseudoraphe) rarely wanting; valve without a slit (raphe).

*c.* Cells usually little shorter than broad, or longer, with numerous interzones, mostly united in filaments. Family 4. *Tabellariaceae,* page 44.

*cc.* Cells usually much shorter than broad (rod-shaped of older authors, the longer axis of the rod representing one of the transverse axes of the cell), often united in filaments.

*d.* Cells cuneate in girdle view (*i.e.,* valves not parallel), rachis median, interzones present. Family 5. *Meridionaceae,* page 47.

*dd.* Cells rectangular in girdle view, or if cuneate, the rachis not median; interzones present or absent. Family 6. *Fragilariaceae,* page 49.

*bb.* Rachis containing an elongated slit (raphe) through the cell wall.

*c.* Rachis commonly median, often more or less lateral, not keeled, or when keeled not punctate; interzones present or absent. Family 7. *Naviculaceae,* page 60.

*cc.* Rachis lateral, less often median, punctate-keeled, raphe not plainly visible. Family 8. *Bacillariaceae,* page 130.

*bbb.* Rachis evident as a narrow, unmarked strip, or keeled, valve with two lateral wing keels, each enclosing a raphe. Family 9. *Surirellaceae,* page 145.

KEY TO THE GENERA

Order *EUPODISCALES*

Family 1. COSCINODISCACEAE

*A.* Cells forming filaments; girdle side marked.
1. *Lysigonium* (*Melosira*), page 36.
*AA.* Cells single; girdle side not marked.
*b.* Valve with distinct central and marginal portions.
2. *Cyclotella*, page 39.
*bb.* Central and marginal portions of the valve grading into one another.
*c.* With marginal spines.
3. *Stephanodiscus*, page 40.
*cc.* Without marginal spines.
4. *Coscinodiscus*, page 41.

Family 2. CHAETOCEROTACEAE

5. *Chaetoceros*, page 42.

Family 3. BIDDULPHIACEAE

6. *Biddulphia*, page 43.

Order *NAVICULALES*

Family 4. TABELLARIACEAE

*A.* Transverse ribs of the valves, when present, not extending into the cell cavity.
*b.* Valves with a few prominent transverse ribs.
7. *Tetracyclus*, page 44.
*bb.* Valves tranversely striate.
8. *Striatella* (*Tabellaria*), page 45.
*AA.* Transverse ribs of the valves extending deeply into the cell cavity.
9. *Denticula*, page 46.

Family 5. MERIDIONACEAE

*A.* Valves punctate or variously punctate-striate, without transverse ribs.
10. *Sceptroncis* (*Opephora, Peronia*), page 47.
*AA.* Valves finely striate and with transverse ribs.
11. *Meridion*, page 48.

Family 6. FRAGILARIACEAE

*A.* Rachis median.
*b.* Valves with transverse ribs, or if not ribbed, with a central clear space (pseudoocellus).
12. *Odontidium* (including *Diatoma*), page 49.

*bb.* Valves without transverse ribs and without central clear space.
*c.* Cells in filaments.
13. *Fragilaria,* page 51.
*cc.* Cells single or forming fan-like, stalked clusters.
14. *Synedra,* page 53.
*ccc.* Cells in radiating clusters.
15. *Asterionella,* page 57.

*AA.* Rachis near one margin.
*b.* Rachis nearly on ventral margin, not interrupting the striations.
16. *Eunotia,* page 57.
*bb.* Rachis somewhat removed from ventral margin, interrupting the striations.
17. *Ceratoneis,* page 60.

## Family 7. NAVICULACEAE

*A.* Valves parallel.
*b.* Frustules with marginal septa.
18. *Mastigloia,* page 61.
*bb.* Frustules without marginal septa.
*c.* Rachis of valves not keeled.
*d.* Raphe straight or nearly so.
*e.* Raphe with a simple border.
*f.* Septa of interzones when present not fenestrated.
*g.* Cells straight in girdle view.
*h.* Central nodule round.
*i.* Valves flat, raphe straight.
19. *Navicula,* page 62.
*ii.* Valves convex; raphe slightly sigmoid.
20. *Scoliopleura,* page 94.
*hh.* Central nodule elongated transversely, forming a stauros.
21. *Stauroneis,* page 95.
*hhh.* Central nodule elongated longitudinally into four horns.
22. *Diploneis,* page 97.
*gg.* Cells curved in girdle view.
23. *Achnanthes,* page 98.
*ff.* Septa of interzones fenestrated; only one valve with a raphe.
24. *Cocconeis,* page 100.
*ee.* Raphe bordered by two ridges.
25. *Brebissonia,* page 103.
*dd.* Raphe strongly sigmoid or arcuate.
26. *Gyrosigma* (*Pleurosigma*), page 104.

*cc.* Rachis of valves with a keel.

27. *Amphiprora*, page 107.

*AA.* Valves not parallel; ends approximating.

*b.* Cells straight in girdle view.

28. *Gomphonema*, page 107.

*bb.* Cells curved in girdle view.

29. *Rhoicosphenia*, page 114.

*AAA.* Valves not parallel; edges approximating.

*b.* Valves without transverse ribs.

*c.* Girdle narrow, not striate.

*d.* Terminal nodules near apices; raphe more or less arcuate.

30. *Cymbella*, page 115.

*dd.* Terminal nodules distant from the apices; raphe straight.

31. *Encyonema*, page 122.

*cc.* Girdle broad, striate.

32. *Amphora*, page 124.

*bb.* Valves with transverse ribs; raphe not evident.

33. *Cystopleura* (*Epithemia*), page 125.

Family 8. BACILLARIACEAE

34. *Homococladia* (*Nitzschia*), page 130.

Family 9. SURIRELLACEAE

*A.* Valve surface undulate.

35. *Sphinctocystis* (*Cymatopleura*), page 145.

*AA.* Valve surface not undulate.

*b.* Valves cuneate, reniform, elliptical, or linear.

36. *Surirella*, page 147.

*bb.* Valves sub-circular, saddle-shaped.

37. *Campylodiscus*, page 150.

Family 1. COSCINODISCACEAE

Cells short and disc-like, or the length sometimes three or four times the diameter; ends striate or punctate, not ribbed. Cells in long filaments or separated into single cells; often with short spines, but no horns. Chromatophores of numerous minute plates.

## Lysigonium

**Lysigonium** Link in *Nees Hor. phys. berol., p. 4. 1820.*

Etym., Gr. λύσιος, dissolving, and γόνια, joints, from the appearance of the filaments which resemble filamentous algae, but break apart early.

*Meloseira* Ag. *Syst. Alg., p. 14. 1824.*

Cells spherical to cylindrical, closely united in filaments; valve view circular, simply punctate. Chromatophores small rounded or irregular plates which are distributed irregularly on the wall of the cell. Auxospore formation asexual. One enlarged daughter cell is produced from one mother cell; cell axis of the daughter cell is parallel or perpendicular to that of the mother cell. In the first case the daughter cell remains within the mother cell and separates the mother chain.

*A.* Junction surfaces of the cells convex. 1. *L. varians.*
*AA.* Junction surfaces of the cells plane, often denticulate.
*b.* Cells with a sulcus near the sutural margin.
*c.* Length of the cells usually not much greater than the width; with distinct granules. 2. *L. distans.*
*cc.* Length of the cells usually greater than the width; with fine granules. 3. *L. crenulatum.*
*bb.* Cells without a sulcus on each side of the connecting zone. 4. *L. granulatum.*

1. **Lysigonium varians** (Ag.) D. T. *Alg. Alg. Abyss. 1891.*
*Meloseira varians* Ag. *Consp. 1830.*

Pl. 1, figs. 1–5.

Cells in pairs; ends of cells convex, covered with fine puncta between which are some coarse dots; sides of cells with fine puncta intermixed with some coarser dots, with a row of coarse beads near the margin; connecting zone between two cells finely striate. Sporangial cells almost globular (figs. 3–5). Diameter 8–35 $\mu$. A form 4–5 $\mu$ in diameter seems to belong to this species.

In creeks, rivers, ponds, ditches, lakes, etc. Andrews, Anselmo, Burge, Callaway, Cedar Creek, Central City, Cody Lake, Crawford, Dismal River, Dunning, Emerald, Emmett, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Hyannis, Ithaca, Lakeside, Lincoln, Long Pine, Melia, Milford, New Helena, Newport, Norfolk, Orella, Pelican Lake, Red Cloud, Ruby, Seward, South Bend, St. Michael, St. Paul, Stanton, Tekamah, Thedford, Valentine, West Point, Whitman.

Fossil: Agate, Greeley County, Hay Springs, Loup City, Merriman, Spalding, Thedford, Williams's Canyon.

Chippewa Falls, Wis.; Blackpipe, Conata, Little White River, Rapid City, S. Dak.; Stockton, Cal.; Blackhand, Granville, New Concord, Put-in Bay, Ohio.

2. **Lysigonium distans** (Kütz.) Kuntze. *Rev. Gen. Plant., II, p. 902. 1891.*

*Meloseira distans* Kütz. *Bacill., p. 54, pl. 2, fig. 12. 1844.*

Pl. 1, figs. 6–10.

End of cell flat, 4–20 μ in diameter, covered with large scattered dots; sides of cell covered with granular striations, 13–14 in 10 μ, slightly spiral; ends of cell with a row of marginal spines. End view shown in fig. 10.

Among moss with *Spirogyra* at Snake River Falls, Culbertson; with other algae at Oakdale, Scottsbluff, Valentine.

Fossil: Agate.

Stockton, Cal.

3. **Lysigonium crenulatum** (Kütz.) Kuntze. *Rev. Gen. Plant., II, p. 902. 1891.*

*Meloseira crenulata* Kütz. *Bacill., p. 55, pl. 2, fig. 8. 1844.*

*Gallionella crenulata* Ehr. *Verb., pl. 2, fig. 41. 1843.*

Pl. 1, figs. 11–13.

End of cell plane, finely punctate, puncta scattered; margins showing well-marked teeth; cells much longer than broad, showing near the end of the cell a faint sulcus; sides of the cell striate, with striations usually somewhat oblique, about 18 in 10 μ, consisting of somewhat elongated puncta. Diameter, 2.5–20 μ; length of cell, 12–17 μ.

Crawford, Oakdale, St. Paul, Snake River, Thedford, Wann.

Fossil: Loup City.

Belvidere, Blackpipe, S. Dak.; Stockton, Cal.

4. **Lysigonium granulatum** (Ehr.) Kuntze. *Rev. Gen. Plant., II, p. 902. 1891.*

*Gallionella granulata* Ehr. *Verb., p. 127. 1843.*

*Meloseira granulata* Ralfs in *Pritch. Inf., p. 820. 1861.*

Pl. 1, figs. 14–15.

End of cell plane with large granules, scattered, indistinct; margin much indented; cells without sulcus, elongated, the sides with very coarse, distinct granules arranged in longitudinal lines, 7–9 in 10 μ. Diameter, 5–17.5 μ.

In ponds, lakes, creeks, etc. Atkinson, Brownlee, Chadron, Dewey Lake, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Pelican

Lake, Red Cloud, Seneca, Valentine.
Fossil: Thedford.
Turtle River, S. Dak.

## 2. Cyclotella

**Cyclotella** Kütz. *Bacill., p. 50. 1844. Syn. Diat., p. 7. 1833.* (Only as a division, not as a generic name.)

Etym., diminutive of Greek κύκλος, circle.

Cells usually single or in pairs, not in filaments, short-cylindrical, disciform, hence usually seen in end view, divided into two parts, the outer with more or less fine, smooth or punctate striations, sometimes with scattered spines, without dots, or irregularly punctate; the central part sometimes swollen. Girdle face straight or undulate. Auxospores formed asexually, single from one mother cell.

*A.* Margin strongly striate and center coarsely punctate. 1. *C. striata.*
*AA.* Not with marginal striations and coarsely punctuate center.
*b.* Center with triangular dots. 2. *C. antiqua.*
*bb.* Center without triangular dots.
*c.* Marginal striations mixed with heavier striations at regular intervals. 3. *C. comta.*
*cc.* Striations all alike. 4. *C. meneghiniana.*

1. **Cyclotella striata** (Kütz.) Cl. & Grun. *Arct. Diat., p. 119. 1880.*

*Coscinodiscus striatus* Kütz. *Bacill., p. 131, pl. 1, fig. 8. 1844.*

Pl. 1, fig. 22.

End of cell with distinct marginal ring, 5–6 μ wide, of coarse striations, 7–12 in 10 μ; diameter of cells, 30–80 μ.

In Devils Lake, N. Dak.

2. **Cyclotella antiqua** W. Sm. *Brit. Diat., I, p. 28, pl. 5, fig. 49. 1853.*

Pl. 1, fig. 17.

Cells 15–30 μ in diameter; end of cell with distinct marginal ring of costae, 2–3 μ wide; costae intermixed with spines or coarse dots, about 15 costae and 6 dots in 10 μ; center finely granular with 6–15 triangular elevations.

Grand Island.

3. **Cyclotella comta** (Ehr.) Kütz. *Spec., p. 20. 1849.*
*Discoplea comta* Ehr. in *Ber. Berl. Akad., p. 267. 1842.*
Pl. 1, fig. 18.

End of cell plane with a distinct narrow ring of striations around the margin; striations about 15 in 10 $\mu$, each third or fourth striation much heavier than the others; central portion with radiating puncta, about ten rows in 10 $\mu$ at outside margin of central portion; diameter of cell, 7.5–40 $\mu$. The form described as var. *radiosa* Grun. in *V. H. Diat., p. 447, pl. 22, fig. 654,* agrees fully with the specimens found.

In creek, Anselmo.
Devils Lake, N. Dak.

4. **Cyclotella meneghiniana** Kütz. *Bacill., p. 50, pl. 30, fig. 68. 1844.*
Pl. 1, figs. 19–21.

End of cell undulate with robust marginal striations, delicately punctate; central portion 5–10 $\mu$ in diameter, with fine radiating dots and one or two coarse dots almost in the center; striations 7–9 in 10 $\mu$; diameter of cell, 10–24 $\mu$.

In springs, creeks, ponds, etc., with higher algae: Benkleman, Broken Bow, Cedar Creek, Central City, Clear Lake, Cody Lake, Crawford, Dismal River, Dunning, Emerald, Fremont, Gordon Creek, Grand Island, Hyannis, Halsey, Lakeside, Lincoln, Lodi, Louisville, Melia, Milford, New Helena, North Platte, Northport, St. Paul, Scottsbluff, Seneca, Seward, Stanton, Stromsburg, Talmage, Tekamah, Thedford, Valentine, Wann, Weeping Water, West Point.

Fossil: Cherry County, Hay Springs, Loup City, Thedford.

Blackpipe, Kadoka, Norris, Rosebud, Weta, S. Dak.; fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Stockton, Cal.; Muskingum River, Put-in Bay, pond on island in Lake Erie, Ohio.

### 3. Stephanodiscus

**Stephanodiscus** Ehr. in *Berl. Akad., p. 80. 1845.*

Etym., Gr. στέφανος, crown, and δίσκος, disk, from the crown-like appearance of the cells.

Valves circular, somewhat convex, marked with granules arranged radially; spaces between the rows of granules hyaline; center hyaline or granular; margin with a single row of spines.

*A.* Marginal dots elongated like ribs. 1. *S. carconensis.*
*AA.* Marginal dots not elongated; striations extending nearly to the center. 2. *S. niagarae.*

1. **Stephanodiscus carconensis** (Eulenst.) Grun. *Diat. Kasp. Meer., p. 128. 1878.*

Pl. 1, fig. 23.

Cell disk-shaped, plane, 30–40 $\mu$ in diameter; striations about 15 in 10 $\mu$, granular, radiating, the center filled with scattered granules; marginal dots elongated like ribs, about 6 in 10 $\mu$; margin with a row of spines.

Devils Lake, N. Dak.

2. **Stephanodiscus niagarae** Ehr. in *Ber. Berl. Akad., p. 80. 1845.*

Pl. 1, figs. 24–25.

Cells disk-shaped, plane, 25–60 $\mu$ in diameter, striations granular, about 16 in 10 $\mu$, radiating, extending nearly to the center, the center filled with scattered granules; the margin with a row of spines, about 4 in 10 $\mu$.

Benkleman.
On rocks in creek, Cheyenne, Wyo.

## 4. Coscinodiscus

**Coscinodiscus** Ehr. in *Abh. Berl. Akad., p. 128. 1838.*

*Symbolophora* Ehr., 1844; *Odontodiscus* Ehr., 1845; *Heterostephania* Ehr., 1854; *Cestodiscus* Grev., 1865; *Cosmiodiscus* Grev., 1866; *Stoschia* Janisch, 1885.

Etym., Gr. κόσκινον, sieve, and δίσκος, disk.

Cells single, circular, or sometimes elliptical; ends (valves) flat, concave, or swollen; no ribs, septa, or processes except sometimes very small teeth.

**Coscinodiscus lacustris** Grun. in *Cleve & Grun. Arct. Diat., p. 114. 1880.*

Pl. 1, fig. 26.

Circular or sometimes broadly oval, 20–70 $\mu$ in diameter; puncta radiating, in double rows on the margin, becoming single toward the center, 4–5 rows in 10 $\mu$ on the margin, some of the rows

extending to the center, leaving no central space; teeth fine, about 6 in 10 $\mu$.

In Platte River, Grand Island; Put-in Bay, pond on island in Lake Erie, Ohio.

In San Joaquin River, Stockton, Cal.

### Family 2. CHAETOCERATACEAE

Cells short, usually in filaments, cylindrical or flattened. Valves alike, terminated by a hood, pointed with a bristle; or frustules with valves unlike, mostly smooth; furnished with awns, horns, spines, or setae; often imperfectly siliceous; with a long central spine.

### 5. Chaetoceros

**Chaetoceros** Ehr. in *Ber. Berl. Akad., p. 198. 1844.*

*Bacteriastrum* Shadb., 1853; *Actiniscus* Ehr., 1854.

Etym., Gr. χαίτη, bristle, and κέρας, horn, referring to the long awns.

Valves convex, elliptic or circular with very long awns; cells usually united in long cylindrical filaments.

**Chaetoceros elmorei** Boyer, *A New Diatom,* in *Proceedings of The Academy of Natural Sciences of Philadelphia, p. 219. March, 1914.*

Pl. 1, figs. 27–33.

Filaments straight, 23 $\mu$ wide. Cells rectangular with sharp angles; valves slightly convex; foramina narrowly linear, irregular, bipartate. Setae straight, hollow, approaching each other at an acute angle and crossing at a right angle near the corners of the valves, about ten times the length of the valve. In valve view they diverge from each other at an angle of about 80°. Terminal setae shorter than the others, somewhat curved in the direction of the filament. Spores with the primary valve arcuate, secondary valve produced into a subconical frustum. Rarely in free spores the primary valve is covered with minute spines. The valves are joined together near one side by a tubular commissure, from six-tenths to eight-tenths of a micron in thickness, situated near the edge of the valve, usually at unequal distances from each end, and,

so far as noticed, is found near the margin on the same side of all valves of the filament. (Professor Boyer's original description.)

With crustaceans in surface tow, Devils Lake, N. Dak.

### Family 3. BIDDULPHIACEAE

"Cells box-shaped, shorter than broad, or but little longer, transection circular, polygonal, or commonly elliptical; valves with two (rarely one) to more poles, each pole with a projection or horn which is shorter than the cell, or when about its length provided with claws; interzones rarely present."

### 6. Biddulphia

**Biddulphia** Gray in *Arrang. Brit. Plants, I, p. 294. 1831.*

Etym., named after a Miss Biddulph.

"Frustules free or united into filaments, either continuous or in zigzag. Valves elliptic, suborbicular, triangular, quadrangular, etc.; margins even or undulated, usually more or less inflated in the median portion, rarely depressed, showing elevated obtuse processes at the apices, and having also sometimes horn-like processes. Girdle face more or less quadrangular, showing distinctly processes which are not so visible in the valve face. Connective zone very obvious."

**Biddulphia laevis** Ehr. *Ber., p. 122. 1843.*

Pl. 22, figs. 811–812.

"Valve suborbicular or broadly elliptic, bearing near the longitudinal axis two spines, opposite, short, obscure, with punctate radiate striae, somewhat undulate as if engine-turned, delicate, about 15 or 16 in 10 $\mu$, intermixed with abbreviated scattered spines. Girdle face with terminal processes, very short, obtuse, truncate, punctate up to the margin. Connecting zone with delicate striae, about 16 in 10 $\mu$, punctate in quincunx. Length of valve, 50–120 $\mu$." In our specimens the spines are indistinct or lacking.

In Middle Loup River at Dunning and Thedford.

Order *NAVICULALES*

Family 3. TABELLARIACEAE

Rachis a narrow unmarked strip, no raphe, cells usually little shorter than broad, or longer, mostly in filaments; valves symmetrical, long-elliptic, often swollen in the middle, never cuneate at the ends; with two or more septa; girdle face rectangular.

### 7. Tetracyclus

**Tetracyclus** Ralfs in *Ann. and Mag. Nat. Hist., Vol. XII. 1843.*

Etym., Gr. τέτρα, four, and κόκλος, circle, the valve being divided into four circular portions.

Cells tabulate, united in short bands by numerous interzones; with somewhat distant and irregular transverse ribs which in girdle view appear as marginal teeth; without nodules; girdle view rectangular; chromatophores granular, scattered.

*A.* Cells inflated in the middle. 1. *T. lacustris.*
*AA.* Cells elliptical, without inflation. 2. *T. rupestris*

1. **Tetracyclus lacustris** Ralfs in *Ann. and Mag. Nat. Hist., Vol. XII, p. 105, pl. 2, fig. 2. 1843.*

Pl. 1, figs. 34–35.

Cells in valve view elongated, much swollen in the middle, 35–65 μ long; transverse ribs 4–12, curved toward the center; striations very indistinct, 25–30 in 10 μ; the girdle side with alternate short ribs; cells in long filaments showing numerous septa.

In moss at Snake Creek Falls, Valentine.
Fossil: Greeley Co., Williams's Canyon.

2. **Tetracyclus rupestris** (A. Br.) Grun. *Oest. Diat., p. 412, pl. 7, fig. 37. 1882.*

*Gomphogramma rupestre* A. Br. in *Rabenh. Süssw. Diat., p. 33, pl. 9, fig. 1. 1853.*

Pl. 1, fig. 36.

Cells in valve view elliptic-lanceolate, 8–25 μ long, usually with 2–5 heavy transverse ribs; striations very delicate, about 18 in 10 μ; cells single or two or three united, in girdle view usually

showing two pairs of septa extending nearly to the middle of the cell.

With *Chara* in creek, Grand Island.

### 8. **Striatella** (*Tabellaria*)

**Striatella** Ag. *Consp. Diat., p. 60. 1832.*

Etym., diminutive of Lat. *stria,* striations, on account of the conspicuous striations.

*Tabellaria* Ehr. in *Ber. Berl. Akad., p. 217. 1840.*

Cells in girdle view rectangular, tabulate; at first attached and joined in bands, soon separated and united at the angles by a gelatinous isthmus; with plane dissepiments, usually alternate; in valve view cells more or less inflated at the ends and in the middle, transversely striate, without costae. Endochrome granular, scattered. Auxospores two, arising from a single mother cell.

*A.* Median inflation much broader than the terminal, septa numerous. 1. *S. flocculosa.*

*AA.* Median and terminal inflations equal, septa two to four. 2. *S. fenestrata.*

1. **Striatella flocculosa** (Roth) Kuntze. *Rev. Gen. Plant., III, 2, p. 432. 1898.*

*Conferva flocculosa* Roth. *Catal., I, p. 292, pl. 4, fig. 4. 1797.*

*Tabellaria flocculosa* (Roth) Kütz. *Bacill., p. 127, pl. 17, fig. 21. 1844.*

Pl. 1, fig. 37.

Cells linear, 20–40 $\mu$ long, middle inflated more than the ends; striations punctate, about 13 in 10 $\mu$, lacking in the central inflation; pseudoraphe narrow; girdle face narrow, showing numerous (4–8) false septa.

Thedford.

2. **Striatella fenestrata** (Kütz.) Kuntze. *Rev. Gen. Plant., III, 2, p. 432. 1898.*

*Tabellaria fenestrata* Kütz. *Bacill., p. 127, pl. 17, fig. 22. 1844.*

Pl. 1, figs. 38–39.

Cells linear, 50–100 $\mu$ long, middle and apices nearly equally inflated; pseudoraphe narrow, dilated at the inflations; striations

punctate, 10–12 in 10 $\mu$; girdle face narrow, showing from 2 to 4 false septa.

Atkinson.
Fossil: Mullen.
Chippewa Falls, Wis.; Stockton, Cal.

## 9. Denticula

**Denticula** Kütz. *Bacill., p. 43. 1844. em. Grun. in Wien. Verh., XII, p. 546. 1862.*

Etym., diminutive of Lat. *dens,* tooth, on account of the tooth-like ribs.

Valves lanceolate, without raphe, with a row of transverse septa appearing like ribs, between which are transverse granular or pearl-like striations; rectangular in girdle view; transverse ribs capitate, reaching to the girdle; cells free, single or united in short filaments.

*A.* Apices obtuse. 1. *D. elegans.*
*AA.* Apices acute. 2. *D. tenuis.*

1. **Denticula elegans** Kütz. *Bacill., p. 14, pl. 17, fig. 5. 1844.*
Pl. 2, figs. 40–43.

Cells linear-lanceolate with apices obtusely rounded, 20–35 $\mu$ long; carina obscure; 2.5–5 costae in 10 $\mu$; striations distinct, coarsely punctate, 15–17 in 10 $\mu$; girdle face very broad, rectangular with rounded angles showing the capitate apices of the costae. A curved form is shown in fig. 41.

With *Spirogyra,* etc.: Andrews, Anselmo, Benkleman, Cairo, Clear Lake, Crawford, Dunning, Grand Island, Lakeside, Long Pine, North Platte, Northport, Rupert, St. Paul, Seneca, Sheridan County, Snake River, Thedford, Trenton, Valentine.

Fossil: Agate, Cherry County, Mullen.

Blackpipe, Cutmeat, Rosebud, Turtle River, S. Dak.; Devils Lake, N Dak.; Cheyenne, Wyo.

2. **Denticula tenuis** Kütz. *Bacill., p. 43. 1844.*
Pl. 2, figs. 44–46.

Cells lanceolate, 15–45 $\mu$ long, with apices attenuate to rostrate; carina conspicuous; costae 3–8 in 10 $\mu$; striations fine, 15–17 in

10 $\mu$. The specimens found agree more nearly with *D. inflata* W. Sm., which is probably only a form of *D. tenuis*.

In creek, western Colorado.

## Family 5. MERIDIONACEAE

Rachis a narrow unmarked strip, no raphe; cells usually much shorter than broad, usually in filaments, cuneate in girdle view.

### 10. **Sceptroneis** (*Opephora, Peronia*)

**Sceptroneis** Ehr. in *Ber. Berl. Akad., p. 264. 1844.*

Etym. from Gr. σκῆπτρον, scepter, on account of the rod-like form of the valve.

Cells both in valve and girdle view cuneate, united; without septate girdle or transverse septa; pseudoraphe present, often very broad; terminal nodules sometimes present; valves with transverse beaded striations, beads often united into slit-like or button-hole-like striations.

*A.* With heavy ribs. 1. *S. pacifica.*
*AA.* With delicate striations. 2. *S. fibula.*

1. **Sceptroneis pacifica** (Grun.) Elmore.

*Fragilaria pacifica* Grun. in *Wien. Verh., p. 373, pl. 5, fig. 19. 1862.*

*Opephora pacifica* (Grun.) Petit. *Diat. Cape Horn, p. 130. 1888.*

Pl. 2, figs. 47–50.

Cells ovate, 20–30 $\mu$ long, with very heavy linear-ovate ribs, 5–10 in 10 $\mu$; pseudoraphe narrow.

In ponds, rivers, etc., also fossil: Andrews, Benkleman, Brownlee, Burge, Crawford, Culbertson, Dismal River, Dunning, Fremont, Gordon Creek, Grand Island, Haigler, Halsey, Ithaca, Long Pine, Melia, Norfolk, North Platte, Oakdale, Red Cloud, St. Michael, St. Paul, Seneca, Snake River, Stanton, Valentine, Wann, West Point, Whitman.

Fossil: Greeley County, Mullen, Spalding, Thedford, Valentine.

Blackpipe, Little White River, Rosebud, S. Dak.; Cheyenne, Wyo.; Rodney, Ohio.

2. **Sceptroneis fibula** (Breb.) Schütt in *Eng. & Prant. Natur. Pflanz., I, Ib, p. 109. 1900.*

*Gomphonema fibula* Breb. in *Kütz. Spec. Alg., p. 65. 1829.*
*Peronia erinacea* Breb. & Arnott in *Micr. Jour., p. 16. 1868.*
*Sceptroneis erinacea* (Breb. & Arnott) Schütt *l.c.*
Pl. 2, figs. 51–53.

Cells cuneate both in valve and girdle view with upper end capitate, 40–50 $\mu$ long; terminal nodules distant from the ends; striations rather broad but indistinct, 15–16 in 10 $\mu$, every fourth or fifth striation heavier than the others, interrupted by a pseudoraphe; girdle face with marginal striations; many of the cells variously distorted, as in fig. 52; stipitate, single or from two to four cohering.

Phalaris Lake, and in rapidly-flowing water at Long Pine, Tekamah. Conata, Norris, S. Dak.

### 11. Meridion

**Meridion** Ag. *Syst. Alg., p. XIV, 2. 1824.*
Etym. from Gr. μερίζω, divide.
*Eumeridion* Kütz. *Bacill., p. 42. 1844.*
*Oncosphenia* Ehr. in *Ber. Berl. Akad., p. 72. 1845.*

Cells resembling *Denticula;* valves with transverse septa between which are delicate granular striations, the striations but not the septa interrupted by a clear space (pseudoraphe) which is very delicate and often very difficult to distinguish; general form in valve view linear-lanceolate with the modification that it tapers in wedge form from apex to base; ends rounded, the larger end often capitate by a neck-like constriction just below the pole; cells in girdle view wedge-shaped with straight margins and truncate ends, the septa and striations extending to the girdle. After division the cells remain attached to each other so that the cells form filaments which vary according to the number of cells from fan-shape to circular. When a large number are formed the filament is wound spirally around the central axis. In the filament the septa of neighboring cells correspond with one another so that in the filament the septa form unbroken concentric lines. Filaments floating free. Chromatophores numerous, small.

**Meridion circulare** Kütz. *Bacill., p. 41, pl. 7, fig. 16. 1844.*

Pl. 2, figs. 54–56.

Cells oval, lanceolate, or clavate, 25–35 $\mu$ long, with apices rounded, obtuse; about 16 striations and 3 ribs in 10 $\mu$; pseudoraphe indistinct; girdle face cuneate, with margins somewhat undulated by the beginning of the ribs; cells united in a spiral filament. *Meridion constrictum* Ralfs seems to be merely a form of *M. circulare,* all gradations between the two being found.

In creeks, springs, etc., also fossil: Ashland, Central City, Dunning, Gordon Creek, Halsey, Long Pine, St. Paul, Thedford.

Fossil: Agate, Merriman, Mullen, Williams's Canyon.

Chippewa Falls, Wis.; Conata, Little White River, Rapid City, S. Dak.; Sully's Hill, N. Dak.; Blackhand, Granville, New Concord, Rio Grande, Rodney, Ohio.

## Family 6. FRAGILARIACEAE

Rachis a narrow unmarked strip, no raphe; cells generally shorter than broad; often in filaments, or sessile and nearly separated, adhering together at one end, forming fan-shaped colonies; generally rectangular in girdle view.

### 12. Odontidium

**Odontidium** Kütz. *Bacill., p. 44. 1844. em. Kirchn. Alg. Schles., p. 204. 1878.*

*Diatoma* DC. *Fl. Franc., II, p. 48. 1805. em. Heib. Consp. Diat. Dan., p. 55. 1863.*

Etym., Gr. ὀδούς, tooth, and ἴδιος, like, from the tooth-like appearance of the ribs.

Cells united in short bands or zigzag chains which are attached at the base; valves lanceolate to linear with transverse ribs and fine transverse striations, the latter interrupted centrally by an indistinct pseudoraphe; no central nodule; chromatophores granular.

*A.* Costae delicate; cells united in zigzag chains.
- *b.* Broadly lanceolate. — 1. *O. vulgare.*
- *bb.* Linear with ends capitate. — 2. *O. elongatum.*

*AA.* Costae coarse; cells in short filaments.
- *b.* Ends rounded. — 3. *O. hiemale.*
- *bb.* Ends capitate or rostrate. — 4. *O. anceps.*

1. **Odontidium vulgare** (Bory) Elmore.
*Diatoma vulgare* Bory. *Class. Dict., pl. 20, fig. 15. 1828.*
Pl. 22, figs. 813–814.
Cells broadly lanceolate to almost elliptical, sometimes slightly produced at the apices; 40–60 μ long, 10–14 μ wide; ribs 5–7 in 10 μ, striations finely granular, 14–16 in 10 μ; pseudoraphe indistinct; cells united in zigzag chains.

In Wood River at Grand Island.
Put-in Bay, Pond on Island in Lake Erie, Ohio.

2. **Odontidium elongatum** (Ag.) Kuntze. *Rev. Gen. Plant., III, 2, p. 418. 1898.*
*Diatoma elongatum* Ag. *Syst. Alg., p. 4. 1824.*
Pl. 2, figs. 57–61.
Linear, 37–70 μ long, 4–5 μ wide, apices capitate; costae delicate, about 7 in 10 μ; striations fine, about 17 in 10 μ.

Devils Lake, N. Dak.; Stockton, Cal.

3. **Odontidium hiemale** (Ag.) Kütz. *Bacill., p. 44, pl. 17, fig. 4. 1844.*
*Fragilaria hyemalis* Ag. *Syst. Alg., p. 7. 1824.*
Pl. 2, figs. 62–65.
Cells lanceolate or elliptical, sometimes with apices produced (fig. 63), 15–50 μ long, ribs 2.5–3 in 10 μ, striations 18–20 in 10 μ. Var. *mesodon, O. mesodon* Kütz., is a form more nearly like the specimens found.

Bellevue.
Fossil: Cherry Co.
Chippewa Falls, Wis.

4. **Odontidium anceps** (Ehr.) Elmore.
*Diatoma anceps* (Ehr.) Grun.
Pl. 22, fig. 815.
Linear with apices rostrate or capitate, 20–50 μ long, 5–7 μ wide; striations about 21 in 10 μ; 6–14 heavy costae which are more or less oblique; cells rectangular in girdle view.

In lake, Estes Park, Colo.

## 13. Fragilaria

**Fragilaria** Lyngb. *Hydrophyt. Dan., p. 182. 1819.*

Etym., Lat. *fragilis,* fragile, the filaments resembling filamentous algae, but easily broken apart.

Cells united in mostly ribbon-like, rarely zigzag chains, cells symmetrical in all three planes; girdle view rectangular, mostly narrowly linear; valves linear-lanceolate or fusiform, flat, transversely striate or with transverse rib-like beaded markings, but no true ribs; pseudoraphe present; no nodules.

*A.* Pseudoraphe narrow, scarcely visible. 1. *F. virescens.*
*AA.* Pseudoraphe distinct.
*b.* Striations of distinct beads. 2. *F. capucina.*
*bb.* Striations heavy with beads more or less confluent.
*c.* Small, broadly oval or cruciform.
*d.* Varying from cruciform to constricted in the middle. 3. *F. construens.*
*dd.* Regularly oval. 4. *F. mutabilis.*
*cc.* Cruciform with heavy costae. 5. *F. harrisonii.*

1. **Fragilaria virescens** Ralfs in *Ann. and Mag. Nat. Hist., XII, pl. 2, fig. 6. 1843.*

*Fragilaria virescens* Kütz. *Bacill., p. 46, pl. 16, fig. 4. 1844.*

Pl. 2, figs. 66–67.

Cells linear or linear-elliptic with apices attenuate and often rostrate-obtuse, 20–60 $\mu$ long; striations distinctly punctate, 15–18 in 10 $\mu$, extending nearly across the valve, scarcely leaving a rachis.

Hackberry Lake.
Fossil: Cherry Co.

2. **Fragilaria capucina** Desmaz. *Crypt. de Franc., Ed. I, No. 453. 1825.*

Pl. 2, figs. 68–72.

Valves linear, narrow with apices more or less rostrate, 23–60 $\mu$ long; in the form called var. *mesolepta,* fig. 72, constricted in the middle; margin of the valve with very distinct beads which extend across the valve as delicate striations, leaving a narrow pseudoraphe, 14–15 in 10 $\mu$; cells united in long band-like filaments.

In still or slowly running water, especially common in stock tanks, also fossil: Andrews, Bellevue, Cody Lake, Crawford, Culbertson, Dismal

River, Dunning, Durly Lake, Grand Island, Hackberry Lake, Hastings, Ithaca, Johnson, Lakeside, Long Pine, Milford, North Platte, Pelican Lake, Plattsmouth, Ruby, Seneca, St. Michael, Stromsburg, Talmage, Thedford, Valentine, West Point, Whitman.

Fossil: Cherry County, Loup City, Williams's Canyon.

Cutmeat, Dallas, Kadoka, Rapid City, Turtle River, S. Dak.; Devils Lake, N. Dak.; Stockton, Cal.; Put-in Bay, Ohio.

3. **Fragilaria construens** (Ehr.) Grun. in *Wien. Verh., p. 371. 1862.*

*Staurosira construens* Ehr. *Abh., p. 424. 1841.*

Pl. 2, figs. 73–84; pl. 22, fig. 816.

Very variable, from oval to cruciform, or sometimes contracted in the middle, 11–16 $\mu$ long; rachis lanceolate, striations 10–18 in 10 $\mu$; cells united in short filaments. Var. *venter* and var. *binodis* have been described, but they are probably mere forms.

Very common in creeks, rivers, ponds, etc., especially where the water is quiet and conditions for algae are good, also fossil: Andrews, Burge, Clear Lake, Crawford, Culbertson, Dewey Lake, Dismal River, Dunning, Gordon Creek, Grand Island, Halsey, Ithaca, Long Pine, Melia, New Helena, Niobrara River, Norfolk, North Platte, Oakdale, O'Neill, Red Cloud, Seneca, Thedford, Valentine, West Point.

Fossil: Agate, Cherry County, Hay Springs, Greeley County, Loup City, Merriman, Mullen, Spalding, Thedford, Wheeler County, Williams's Canyon.

Turtle River and Rosebud, S. Dak.

4. **Fragilaria mutabilis** (W. Sm.) Grun. *Oest. Diat., p. 369. 1882.*

*Odontidium mutabile* W. Sm. *Brit. Diat., II, p. 17, pl. 34, fig. 290. 1856.*

Pl. 2, fig. 85; pl. 22, fig. 817.

Cells from almost circular to oval, elliptical, or linear-acuminate, 5–25 $\mu$ long; striations distinct, not resolvable into beads, 7–10 in 10 $\mu$.

St. Paul, Seneca, Snake Creek.

Fossil: Cherry County, Mullen, Wheeler County.

Blackpipe, S. Dak.

5. **Fragilaria harrisonii** (W. Sm.) Grun. *Oest. Diat., p. 369. 1882.*

*Odontidium harrisonii* W. Sm. *Brit. Diat., II, p. 18. 1856.*

Pl. 2, fig. 86.

Cells cruciform, 20–50 μ long; striations very distinct, shortened, leaving a broad rachis, 4–5 in 10 μ.

Burge, Long Pine, North Platte, St. Paul, Valentine.
Fossil: Agate.
Blackpipe, Rapid City, S. Dak.

## 14. Synedra

**Synedra** Ehr. in *Ber., p. 40. 1830.*

Etym., Gr. συνέδριον, sitting together, the cells being united in clusters.

*Desmogonium* Ehr.; *Echinella* Breb.; *Exilaria* Grev.; *Tabularia* Kütz.

Cells usually attached, single or in fan-shaped clusters, sessile or stipitate; very much elongated, more or less lanceolate-linear, sometimes more or less wrinkled; usually with a pseudoraphe, sometimes with false central and polar nodules; chromatophores, two plates with lobed margins.

*A.* Striations extending throughout nearly the breadth of the valve.
  *b.* Valves with a pseudonodule. 1. *S. pulchella.*
  *bb.* Without a pseudonodule.
    *c.* With median hyaline space (hyaline space sometimes lacking).
      *d.* Narrowly linear-lanceolate.
        *e.* Striations distinct, about 13 in 10 μ. 2. *S. tenuissima.*
        *ee.* Striations fine, 16–18 in 10 μ. 3. *S. radians.*
      *dd.* Linear-oblong or lanceolate. 4. *S. familiaris.*
      *ddd.* Narrowly linear. 5. *S. ulna.*
    *cc.* Without median hyaline space.
      *d.* Very large with apices triangular-capitate. 6. *S. capitata.*
      *dd.* Not triangular-capitate.
        *e.* Cells large. 5. *S. ulna.*
        *ee.* Cells small.
          *f.* Striations and pseudoraphe distinct. 7. *S. amphicephala.*
          *ff.* Striations fine; pseudoraphe indistinct. 8. *S. famelica.*

*AA.* Striations marginal. 9. *S. tabulata.*

1. **Synedra pulchella** Kütz. *Bacill., p. 68, pl. 29, fig. 87. 1844.*
Pl. 3, figs. 91–96.

Narrowly lanceolate with apices slightly rostrate-capitate, 30–60 $\mu$ long; pseudonodule distinct, often reaching to the margins; pseudoraphe narrow, terminated by small nodules; striations 12–14 in 10 $\mu$, distinctly punctate; girdle face linear, attenuated at the ends.

In ponds, lakes, rivers, etc.: Cedar Creek, Culbertson, Dismal River, Grand Island, North Platte, Pelican Lake, Red Cloud, Seneca, Stromsburg.
Fossil: Loup City.
Devils Lake and fresh water near Devils Lake, N. Dak.; Stockton, Cal.

2. **Synedra tenuissima** Kütz. *Bacill., p. 64, pl. 14, fig. 6. 1844.*
*Frustulia tenuissima* Kütz. *Syn. Diat., p. 24, pl. 2, fig. 22. 1834.*
*Synedra acus* Kütz. *Bacill., p. 68, pl. 30, fig. 50. 1844.*
Pl. 3, figs. 97–104.

Narrowly lanceolate with apices slightly rostrate-capitate, sometimes constricted in the middle and sometimes swollen, 45–230 $\mu$ long; pseudoraphe narrow, striations distinct, 12–13 in 10 $\mu$, usually lacking in the center, leaving a rectangular clear space. Very variable, some forms like forms of *S. ulna,* from which it can be distinguished only by the finer striations. Some forms are described as var. *delicatissima,* fig. 97, and var. *angustissima,* figs. 98–99.

With *Cladophora, Oscillatoria, Spirogyra,* and other algae in tanks, creeks, etc.: Cherry County, Crawford, Dewey Lake, Fremont, Hemingford, Holt County, South Bend, Talmage, Tecumseh, Valentine, Weeping Water.
Fossil: Greeley County, Spalding.
Court Lake, Devils Lake, N. Dak.; Cutmeat, S. Dak.; Stockton, Cal.; Put-in Bay, Ohio.

3. **Synedra radians** Kütz. *Bacill., p. 64, pl. 14, fig. 7. 1844.*
Pl. 3, figs. 105–114.

Very narrowly linear-lanceolate, tapering toward the ends, sometimes capitate, 30–100 $\mu$ long; striations delicate, leaving a very narrow pseudoraphe, 16–18 in 10 $\mu$, usually lacking in the middle of the valve, leaving a clear space. Deformed specimens have

been found (figs. 110–114) in tanks at Central City and Stromsburg, Nebraska, and in Put-in Bay, Ohio.

In tanks, ditches, ponds, creeks, and rivers: Cairo, Central City, Crawford, Halsey, Meadow, North Platte, Red Cloud, Scottsbluff, Seneca, Talmage, Tekamah, Thedford.

Fossil: Mullen.

Cheyenne, Wyo.; Chippewa Falls, Wis.; Weta, S. Dak.; Sully's Hill, N. Dak.; Fresno, Stockton, Cal.; Put-in Bay, Ohio.

4. **Synedra familiaris** Kütz. *Bacill., p. 68, pl. 15, fig. 12. 1844.*

Pl. 3, fig. 115.

Linear-oblong or lanceolate, 37–80 $\mu$ long, apices attenuate-rostrate or capitate; striations 13–17 in 10 $\mu$, lacking in the middle, leaving a clear space; center contracted or sometimes swollen; pseudoraphe narrow; cells sometimes cohering in short bands.

In tanks, rivers, etc.: Clear Lake, Dewey Lake, Dismal River, Halsey, Long Pine, Melia, O'Neill, Talmage, Tekamah, Thedford.

Fossil: Greeley County.

5. **Synedra ulna** (Nitz.) Ehr. *Inf., p. 211. 1838.*

*Bacillaria ulna* Nitz. *Beitr., p. 99. 1817.*

Pl. 3, figs. 116–130; pl. 4, figs. 131–139.

Narrowly linear or somewhat lanceolate with ends more or less elongated-rostrate, sometimes capitate, 50–350 $\mu$ long; striations distinct, 9–10 in 10 $\mu$, leaving a narrow pseudoraphe, usually lacking in the middle, leaving a rectangular clear space. Very variable and presenting many forms that have been described as species or varieties; among these are *danica,* figs. 118, 123, 132, 133, and *splendens,* figs. 116, 117, 131. It is impossible to separate these forms from one another. Some of them can be distinguished from *S. tenuissima* only by their coarser striations.

Common in tanks, creeks, ponds, etc., with various algae: Andrews, Anselmo, Arago, Ashland, Battle Creek, Bellevue, Benkleman, Brock, Broken Bow, Burge, Cedar Creek, Central City, Clear Lake, Cody Lake, Columbus, Crawford, Crete, Dewey Lake, Dismal River, Dunning, Emerald, Emmett, Ewing, Fairbury, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Haigler, Halsey, Holt County, Hyannis, Lakeside, Lincoln, Lodi, Long Pine, Meadow, Melia, Milford, New Helena, Newport, Norfolk, North Platte, Northport, Oakdale, O'Neill, Orleans, Pelican Lake, Phalaris Lake, Pleasant Dale, Red Cloud, Ruby, Rupert, St. Michael, St. Paul, Scottsbluff,

Seneca, Seward, Snake River, South Bend, Stromsburg, Talmage, Tekamah, Thedford, Valentine, Wann, Weeping Water, West Point, Whitman, Willow Lake, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Loup City, Merriman, Mullen, Spalding, Thedford, Valentine, Williams's Canyon.

Belvidere, Blackpipe, Cutmeat, Kadoka, Little White River, Norris, Rapid City, Redleaf, Rosebud, Weta, S. Dak.; Devils Lake and fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Fresno, Stockton, Cal.; Blackhand, Granville, New Concord, Put-in Bay, Rio Grande, Ohio.

6. **Synedra capitata** Ehr. in *Poggendorff's Annalen Phys., pl. 3, fig. 3. 1836.*

Pl. 4, fig. 140.

Linear, 200–500 $\mu$ long, apices triangular-capitate, somewhat attenuated at the tip; pseudoraphe narrow; striations distinct, about 8 in 10 $\mu$. This species seems to be somewhat constant in form, but variable in size. The form called *S. ulna* var. *longissima,* figs. 138–139, seems to belong to this species, as all gradations are found between the two.

In springs, etc., with luxuriantly-growing algae and other diatoms: Anselmo, Bellevue, Burge, Gordon Creek, Norfolk, North Platte, Oakdale, St. Paul, Scottsbluff, Seneca, Thedford, Valentine, Woodlake.

Fossil: Agate, Greeley County, Loup City, Merriman, Mullen, Spalding, Thedford, Valentine, Wheeler County.

7. **Synedra amphicephala** Kütz. *Bacill., p. 64, pl. 3, fig. 12. 1844.*

Pl. 4, figs. 141–142.

Very narrowly lanceolate with ends more or less rostrate-capitate, 40–60 $\mu$ long; striations very distinct, 11–12 in 10 $\mu$, leaving a narrow but distinct pseudoraphe.

Atkinson.

Fossil: Agate, Cherry Co.

8. **Synedra famelica** Kütz. *Bacill., p. 64, pl. 14, fig. 8. 1844.*

Pl. 4, fig. 143.

Broadly to narrowly lanceolate; apices rostrate-capitate, 22–30 $\mu$ long; striations 20–21 in 10 $\mu$, leaving a very narrow or indistinct pseudoraphe.

Pool by railroad, Devils Lake, N. Dak.

9. **Synedra tabulata** (Ag.) Kütz. *Bacill., p. 68, pl. 15, fig. 10. 1844.*

*Diatoma tabulatum* Ag. *Consp. Diat., p. 50. 1830.*

*Synedra affinis* var. *tabulata* V. H. *Syn., p. 153. 1885.*

Pl. 4, figs. 144–146.

Lanceolate with ends sometimes slightly rostrate-capitate, 90–175 $\mu$ long; striations short, leaving a very wide pseudoraphe, 10–13 in 10 $\mu$; frustules arranged radially.

Common in brackish water; Arbor, in salt marsh; Lincoln, in Salt Creek; Scottsbluff, Thedford.

Devils Lake and fresh water near Devils Lake, N. Dak.

## 15. Asterionella

**Asterionella** Hassall in *Micr. Exam., p. 10. 1856.*

Etym., diminutive of Greek ἀστήρ, star, referring to the radial arrangement of the cells.

Cells elongated, linear; apices unequally capitate; girdle face linear with apices unequally inflated; cells radially arranged.

**Asterionella gracillima** (Hantzsch) Heiberg. *Consp., p. 68, pl. 6, fig. 19. 1863.*

*Diatoma gracillimum* Hantzsch in *Rabenh. Alg., No. 1104.*

Pl. 2, figs. 88–90.

Valves very narrow, linear, tapering toward the rounded capitate ends, the basal end larger than the other, 42–100 $\mu$ long, about 2 $\mu$ wide in the middle; striations 15–17 in 10 $\mu$, interrupted by a very narrow rachis.

In San Joaquin River, Stockton, Cal.

## 16. Eunotia

**Eunotia** Ehr. in *Ber. Berl. Akad., p. 45. 1837.*

Etym., Gr. εὖ, well, and νῶτος, back, in reference to the strongly curved dorsal margin.

Cells free, or united in filaments; or attached; in girdle view rectangular-oblong, in valve view arcuate, the convex margin often undulate; valves with transverse striations, no ribs, pseudoraphe not evident; polar nodules present, central nodule wanting;

chromatophores small, plate-like; auxospore one from two mother cells.

| | |
|---|---|
| *A.* Cells united in filaments. | |
| *b.* Rostrate-capitate. | 1. *E. arcus.* |
| *bb.* Scarcely capitate. | 2. *E. major.* |
| *AA.* Cells not united in filaments. | |
| *b.* Slightly arcuate. | |
| *c.* With slight median enlargement. | 3. *E. formica.* |
| *cc.* With no median enlargement. | 4. *E. lunaris.* |
| *bb.* More or less wrinkled. | |
| *c.* With two dorsal swellings. | 5. *E. diodon.* |
| *cc.* With several dorsal swellings. | 6. *E. robusta* |
| *ccc.* With both dorsal and ventral swellings. | 7. *E. eruca.* |

1. **Eunotia arcus** Ehr. *Inf., p. 191. 1838.*

Pl. 5, fig. 149; pl. 22, figs. 819–820.

Curved, 30–90 μ long, ends capitate, often only slightly so, ventral margin straight or slightly concave, dorsal margin convex and sometimes undulate, constricted on the dorsal margin near the ends; striations punctate, 12–15 in 10 μ.

Cody Lake, Columbus, Culbertson, Scottsbluff, Thedford.
Fossil: Greeley County, Loup City, Mullen.

2. **Eunotia major** (W. Sm.) Rabenh. *Fl. Eu. Alg., I, p. 72. 1864.*

*Himantidium majus* W. Sm. *Brit. Diat., II, p. 14, pl. 33, fig. 286. 1856.*

Pl. 5, figs. 150–152.

Arcuate with parallel margins, 62–190 μ long, ends obtusely rounded, sometimes capitate; striations finely punctate, 9–12 in 10 μ.

Clear Lake, Dismal River, Dunning, Hackberry Lake, Long Pine, Thedford, Whitman, Woodlake.
Fossil: Agate, Cherry County, Merriman, Mullen.

3. **Eunotia formica** Ehr. *Verb., p. 126. 1843.*

Pl. 5, figs. 153–155.

Arcuate, 70–162 μ long, 8–14 μ wide, width practically the same throughout the entire length; apices rounded or triangular-acute; ventral side gibbous in the middle, dorsal side slightly inflated,

straight or indented in the middle; terminal nodules near the ventral margin; striations distinct, 7–9 in 10 $\mu$. Fig. 153 is the form called var. *elongata* Grun.

With other algae: Dismal River, St. Paul.
Fossil: Greeley County, Mullen.
Little White River, S. Dak.

4. **Eunotia lunaris** (Ehr.) Grun. in *V. H. Syn., p. 144, pl. 35, figs. 2–6. 1885.*
*Synedra lunaris* Ehr. in *Abh. Berl. Akad., p. 87. 1831.*
Pl. 5, figs. 156–162; pl. 22, fig. 818.

Arcuate, 35–143 $\mu$ long, 4–8 $\mu$ wide; width uniform throughout the entire length except at the ends, which are usually slightly constricted on the dorsal margin, making the ends rostrate or capitate; terminal nodules round, distinct, on the ventral side; striations granular, 12–15 in 10 $\mu$. Sometimes the cells have a single or a double curve, making the form called var. *bilunaris* (figs. 160–162).

Common in creeks, ponds, lakes, tanks, etc.: Anselmo, Atkinson, Auburn, Bellevue, Big Alkali Lake, Broken Bow, Brownlee, Cedar Creek, Central City, Clear Lake, Culbertson, Dewey Lake, Dismal River, Dunning, Emerald, Fremont, Grand Island, Hackberry Lake, Halsey, Hyannis, Linsoln, Lodi, Long Pine, New Helena, O'Neill, Osage, Pelican Lake, Peru, St. Michael, Seneca, Talmage, Tekamah, Thedford, Valentine, Wann, West Point, Whitman, Woodlake.
Fossil: Agate, Cherry County, Merriman, Mullen, Spalding, Thedford, Valentine, Williams's Canyon.
Cheyenne, Wyo.; Cutmeat, Rapid City, S. Dak.; Sully's Hill, N. Dak.; Fresno, Stockton, Cal.

5. **Eunotia diodon** Ehr. *Inf., p. 192. 1838.*
Pl. 5, fig. 163.

Slightly arcuate, 34–50 $\mu$ long, 7–8 $\mu$ wide; ventral margin slightly concave, dorsal margin convex with two inflations; apices sometimes capitate, not bent backward; terminal nodules distinct, near the ventral side; striations distinct, 8–10 in 10 $\mu$.

In ponds, rivers, lakes, etc.: Clear Lake, Dismal River, Hackberry Lake, Halsey, Seneca.
Fossil: Agate, Cherry County, Mullen, Valentine.

6. **Eunotia robusta** Ralfs in *Pritch. Inf., p. 763.*

Pl. 5, fig. 164.

Arcuate with nearly parallel margins; dorsal margin with several swellings, ventral margin usually without swellings; 48–90 μ long, 9–10 μ wide; ends rounded; striations perpendicular to the dorsal margin, 9–10 in 10 μ.

In San Joaquin River, Stockton, Cal.

7. **Eunotia eruca** Ehr. *1844.*

Pl. 5, figs. 165–167.

Valves arcuate, 48–88 μ long, 8–12 μ wide; apices produced; both dorsal and ventral margins undulate; striations perpendicular to the dorsal margin, 8–10 in 10 μ.

In San Joaquin River, Stockton, Cal.

### 17. Ceratoneis

**Ceratoneis** Ehr. 1840, Emend. Grun. *Diat. Insl. Banka, p. 7, 1865.*

Etym., Gr. κέρας, horn.

Cells single, free; valves lunate; pseudoraphe nearer to the ventral than to the dorsal side, the ventral side with a swelling opposite the central nodule; terminal nodules more distinct than the central; cells rectangular in girdle view.

**Ceratoneis arcus** (Ehr.) Kütz. *Bacill., p. 104, pl. 6, fig. 10. 1844.*

*Navicula arcus* Ehr. *Inf., p. 182, pl. 21, fig. 10. 1838.*

Pl. 5, figs. 168–169; pl. 22, figs. 821–822.

Valves arcuate, 30–109 μ long, 3–4 μ wide, slightly lanceolate with a median inflation on the ventral side; apices more or less capitate, bent slightly toward the dorsal side; striations finely punctate, perpendicular to the margins, 13–15 in 10 μ.

In San Joaquin River, Stockton, Cal.

## Family 6. NAVICULACEAE

Cells free-swimming, stipitate, enclosed in gelatinous tubes, or occasionally adhering in filaments. Rachis containing a median elongated slit (raphe). Valves with transverse striations which are interrupted by the rachis.

## 18. Mastigloia

**Mastigloia** Thwaites in *W. Sm. Brit. Diat., II, p. 64. 1856.*

Etym., Gr. μαστός, breast, and γλοιός, gelatinous, from the form of the mass in which it grows.

Cells naviculoid with transverse septa between the valve and the girdle; septa on the margins forming regularly arranged compartments, leaving an oval or linear space in the middle of the valve. In girdle view the compartments appear as a row of coarse dots. Valves symmetrical, ends attenuate, capitate, or cuneate; striations fine, granular. Chromatophores double, lying next to the valves, deeply constricted in the middle or consisting of four plates which lie either next to the valves or the girdle, but are not united at the ends.

| | |
|---|---|
| *A.* Marginal cells arranged in a curved row. | 1. *M. smithii.* |
| *AA.* Marginal cells arranged in a straight row. | |
| *b.* Striations consisting of fine dots. | 2. *M. elliptica.* |
| *bb.* Striations consisting of coarse dots. | 3. *M. grevillei.* |

1. **Mastigloia smithii** Thwaites in *W. Sm. Brit. Diat., II, p. 65, pl. 54, fig. 341. 1856.*

Pl. 5, fig. 170.

Lanceolate, more or less rostrate, or sometimes rostrate-capitate, 27–53 μ long, 10–15 μ wide; striations radiate, consisting of dots arranged in longitudinal rows, 12–18 in 10 μ, longitudinal rows closer; shortened, leaving a small round or rectangular space in the center; marginal cells 5–8 in 10 μ, arranged in a curved row, not extending to the ends of the cell.

In fresh water, Court Lake near Devils Lake, N. Dak.

2. **Mastigloia elliptica** (Ag.) Schönf. *Süssw. Fl., p. 63. 1913.*
*Frustulia elliptica* Ag. in *Kütz. Syn. Diat., p. 10. 1833.*
*Mastigloia dansei* Thw. in *W. Sm. Brit. Diat., p. 64, pl. 62, fig. 388. 1856.*

Pl. 5, figs. 171–175.

Elliptical or linear-elliptical, 22–51 μ long, 10–18 μ wide; ends rounded, slightly constricted or cuneate; striations granular, radiate, 15–20 in 10 μ, slightly curved, the middle ones alternately longer and shorter; marginal rows of cells about 8 in 10 μ, not

extending to the ends of the valves. The form described as var. *dansei* Thw., *Schönf. l.c.,* is more nearly represented by figs. 174–175, being more linear with cuneate ends.

Lakeside, North Platte, Scottsbluff.
Devils Lake and fresh water near Devils Lake, N. Dak.

3. **Mastigloia grevillei** W. Sm. *Brit. Diat., II, p. 65, pl. 62, fig. 389. 1856.*

Pl. 5, figs. 176–177.

Linear-elliptical, slightly tapering at the ends, 35–60 $\mu$ long, 10–12 $\mu$ wide; striations coarsely granular, radiating, 10–15 in 10 $\mu$, shortened opposite the central nodule, leaving a rounded hyaline space; marginal rows of cells about 8 in 10 $\mu$.

In pond with *Cladophora,* Scottsbluff.

## 19. Navicula

**Navicula** Bory. *Dict. Class., XI, p. 472. 1826.*

Etym., Lat. diminutive of *navis,* boat, from the boat-shaped valves.

Cells single, free or enclosed in gelatinous tubes, or rarely cohering in chains; elliptical to linear-lanceolate in valve view, rectangular and straight in girdle view; with or without interzones, interzonal septa not marginally chambered; valves bilaterally symmetrical with a straight or slightly curved raphe, no keel; with round central and polar nodules; surface transversely punctate-striate or ribbed. Auxospore formation: two mother cells lying parallel to each other surround themselves with a gelatinous envelope, cast off the old valves, and the contents of the two unite, forming two auxospores which are surrounded by a siliceous sheath (perizonium).

*A.* With costae, *i.e.,* heavy ribs.
  *b.* Costae not composed of rows of dots. 1. *Pinnulariae,* page 63.
  *bb.* Striations heavy appearing like costae, but composed of rows of dots. 2. *Radiosae,* page 71.
*AA.* Striations consisting of rows of dots.
  *b.* Valves with striations interrupted by two sulci near the raphe. 3. *Lyratae,* page 81.
  *bb.* Valves more or less lanceolate, elliptic, or linear-lanceolate, without a sulcus.

*c.* Valves having the appearance of a stauros, either by the absence of striations or by the space between them.
4. *Stauroneideae,* page 81.
*cc.* Valves without any appearance of a stauros.
*d.* Striations with dots not forming longitudinal lines.
*e.* Striations shortened leaving a wide hyaline space along the raphe. 5. *Palpebrales,* page 83.
*ee.* Striations extending nearly to the raphe.
6. *Perstriatae,* page 83.
*dd.* Striations with dots forming straight longitudinal lines.
7. *Crassinerves,* page 83.
*ddd.* Striations with dots forming zigzag horizontal lines.
*e.* Striations interrupted by a sulcus.
8. *Sculptae,* page 86.
*ee.* Striations not interrupted by a sulcus.
9. *Serianteae,* page 87.
*bbb.* Valves with one or more marginal or submarginal sulci.
*c.* Lanceolate, large, striations fine, radiate, leaving a large hyaline space around the central nodule.
10. *Formosae,* page 88.
*cc.* Elongated, more or less triundulate; sulcus marginal, often inconspicuous; raphe surrounded by a narrow, lanceolate hyaline space; striations radiate.
11. *Limosae,* page 88.
*ccc.* Striations nearly perpendicular to the raphe, usually slightly oblique; sulcus broad, distinct. 12. *Affines,* page 90.
*bbbb.* Linear, no sulcus. 13. *Bacillieae,* page 92.
*bbbbb.* Very small, structure indistinct. 14. *Minutissimae,* page 93.

## I. Pinnulariae

*A.* Majores. Cells large, costae broad and heavy.
*b.* Costae shortened leaving a broad hyaline space along the raphe.
1. *N. nobilis.*
*bb.* Costae extending more nearly to the raphe.
*c.* Inflated in the middle. 2. *N. major.*
*cc.* Not inflated in the middle. 3. *N. viridis.*
*AA.* Minores. Cells of medium or small size, costae not so coarse.
*b.* Neither constricted in the middle nor undulate.
*c.* Costae heavy and distant.
*d.* Linear-elliptical or elliptical, striations not extending to the raphe. 4. *N. lata.*
*dd.* Linear, striations reaching nearly to the raphe.
*e.* Striations shortened in the middle.
5. *N. borealis.*

*ee.* Striations lacking in the middle.
6. *N. intermedia.*

*cc.* Costae finer.
*d.* Not inflated in the middle or only slightly so.
*e.* Apices not rostrate-capitate.
*f.* Apices neither inflated nor attenuate.
7. *N. stauroneiformis.*
*ff.* Apices somewhat attenuate.
*g.* Costae delicate. 8. *N. brebissonii.*
*gg.* Costae heavier. 9. *N. rangoonensis.*
*fff.* Apices inflated.
*g.* Slightly or not at all inflated in the middle.
10. *N. parva.*
*gg.* More inflated in the middle.
11. *N. decurrens.*
*ee.* Apices rostrate-capitate.
*f.* Costae distant. 12. *N. subcapitata.*
*ff.* Costae closer. 13. *N. appendiculata.*
*dd.* Inflated in the middle. 14. *N. braunii.*
*bb.* Constricted in the middle or undulate.
*c.* Apices strongly rostrate-capitate.
*d.* Swollen in the middle. 15. *N. mesolepta.*
*dd.* Constricted in the middle. 16. *N. thermes.*
*cc.* Apices slightly rostrate.
*d.* Striations strongly radiate. 17. *N. legumen.*
*dd.* Striations slightly radiate. 18. *N. nodosa.*
*ccc.* Apices rounded or slightly constricted.
19. *N. acrosphaeria.*

1. **Navicula nobilis** (Ehr.) Kütz. *Bacill., p. 98, pl. 4, fig. 24. 1844.*
*Pinnularia nobilis* Ehr. *Abh., p. 20. 1840.*
Pl. 6, figs. 178–182.

Linear-elliptic, slightly swollen in the middle and at the ends, 127–400 μ long, 16–50 μ wide; costae heavy, 4–8 in 10 μ, radiating in the middle, then parallel, and slightly converging at the ends, shortened, leaving a hyaline area along the raphe about one-third the width of the valve.

With luxuriantly-growing algae in rivers, etc.: Clear Lake, Crete. Fossil: Cherry County, Mullen.

2. **Navicula major** Kütz. *Bacill., p. 97, pl. 4, fig. 19. 1844.*
*Pinnularia major* Rabenh. *Süssw. Diat., p. 42, pl. 6, fig. 5. 1853.*

Pl. 6, fig. 184.

Linear-elliptic, more or less swollen in the middle and at the ends, 161–300 μ long, 23–30 μ wide; costae radiating at the center and converging at the ends, coarse, 5–7 in 10 μ, extending more nearly to the raphe than in *N. nobilis*.

With luxuriantly-growing algae in rivers, lakes, ponds, etc.: Aspinwall, Clear Lake, Crawford, Dewey Lake, Dismal River, Fairbury, Grand Island, Hackberry Lake, Halsey, Lakeside, Long Pine, Louisville, New Helena, Red Cloud, Rupert, St. Michael, Seneca, Thedford, Wahoo.

Fossil: Agate, Cherry County, Hay Springs, Loup City, Merriman, Spalding, Thedford, Valentine.

Rosebud, S. Dak.; Stockton, Cal.

3. **Navicula viridis** (Nitz.) Kütz. *Bacill., p. 97, pl. 4, fig. 18; pl. 30, fig. 12. 1844.*

*Bacillaria viridis* Nitz. *Beitr., pl. 6, figs. 1–3. 1817.*

Pl. 6, figs. 185–191.

Linear-elliptic, often slightly oval, without inflations; ends rounded, 20–200 μ long, 11–32 μ wide; costae heavy, 5–8 in 10 μ, extending nearly to the raphe, radiating in the center, converging at the ends.

In ponds, creeks, rivers, ditches, tanks, etc.: Andrews, Arago, Ashland, Aspinwall, Auburn, Broken Bow, Burge, Brownlee, Cairo, Callaway Central City, Clear Lake, Columbus, Crawford, Culbertson, Dewey Lake, Dismal River, Dunbar, Dunning, Fairbury, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Holt County, Lakeside, Lincoln, Lodi, Long Pine, Louisville, Meadow, New Helena, North Platte, O'Neill, Orella, Pelican Lake, Rupert, St. Michael, St. Paul, Seneca, Snake River, Stanton, Stromsburg, Tekamah, Thedford, Trenton, Valentine, Wahoo, Wann, Weeping Water, West Point.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Loup City, Merriman, Mullen, Thedford, Valentine.

Blackpipe, Little White River, Rapid City, Rosebud, Turtle River, S. Dak.; Cheyenne, Wyo.; Court Lake and fresh water near Devils Lake, N. Dak.; Stockton, Cal.; Ft. Collins, Colo.

4. **Navicula lata** (Breb.) Kütz. *Bacill., p. 92, pl. 3, fig. 51. 1844.*

*Frustulia lata* Breb. *Consp. Diat., p. 18. 1838.*

Pl. 7, figs. 192–193.

Linear-elliptical or elliptical, often inflated in the middle, 32–110 μ long, 14–40 μ wide; apices obtuse, broadly rounded; costae

very heavy, 4–6 in 10 μ, slightly radiate in the center and converging at the ends, not reaching to the raphe, those around the central nodule shortened, leaving a round hyaline space.

With luxuriantly-growing *Cladophora* in creeks and ponds: Anselmo Seneca.

Blackpipe, S. Dak.

5. **Navicula borealis** (Ehr.) Kütz. *Bacill., p. 96, pl. 28, figs. 68–72. 1844.*

*Pinnularia borealis* Ehr. *Verb., pl. I, II, fig. 6. 1843.*

Pl. 7, figs. 194–199.

Linear-elliptic, sometimes slightly attenuate, 30–68 μ long; apices rounded or truncate; costae slightly radiate in the middle, converging at the ends, very heavy, 3–6 in 10 μ, reaching almost to the raphe, except those around the central nodule, which are shorter, leaving a round hyaline space. Differs from *N. lata* mainly in its more linear outline.

In ponds, rivers, creeks, pools, ditches, etc.: Ainsworth, Columbus, Crawford, Dismal River, Dunning, Fremont, Grand Island, Long Pine, Milford, Norfolk, North Platte, O'Neill, St. Paul, Stanton, Trenton.

Fossil: Valentine.

Belvidere, Conata, Little White River, Norris, Rapid City, Rosebud, Scenic, S. Dak.; Stockton, Cal.

6. **Navicula intermedia** Lagerst. *Spetz. Diat., p. 23, pl. 1, fig. 3. 1873.*

Pl. 7, figs. 200–205.

Linear-elliptic with rounded ends, 18–42 μ long, 5–8 μ wide; striations heavy, radiating, 9–10 in 10 μ, lacking in the center, leaving a transverse hyaline space.

Fossil: Agate.

Belvidere, S. Dak.

7. **Navicula stauroneiformis** Elmore.

*Pinnularia aestuarii* (Breb.) Cl. *Nav. Diat., II, p. 93, pl. 1, fig. 16. 1895.*

*Navicula aestuarii* Breb. in *Kütz. Spec. Alg., p. 890, 1849,* is *Gyrosigma.*

Pl. 7, figs. 206–207.

Linear with parallel margins and rounded ends, 100–120 μ long, about 16 μ wide; raphe flexuose; striations parallel, shortened, leaving a moderately wide hyaline space along the raphe, entirely lacking in the middle, forming a pseudostauros, 7–10 in 10 μ. The specimens shown in figures 206 and 207 are 82 μ and 37 μ long, respectively, but appear to belong to this species.

Clear Lake.

8. **Navicula brebissonii** Kütz. *Bacill., p. 93, pl. 3, fig. 49; pl. 30, fig. 39. 1844.*

Pl. 7, figs. 208–229.

Linear-elliptic, oblong, or elliptic, sometimes constricted in the middle, 14–68 μ long, 6–13 μ wide; apices varying from obtuse to slightly rostrate-capitate; costae radiating in the center, but toward the ends suddenly becoming convergent, either shortened or entirely lacking around the central nodule, 9–12 in 10 μ; the empty valves usually of a brownish color. Very variable. The following forms have been described: var. *angustata* Grun., very narrow, ends attenuate; var. *linearis* O. Müller, margins straight, ends broad, round; var. *diminuta* V. H., narrower than the typical form, ends always narrowed; var. *notata* Heibrand and Peragallo, a small form with cuneate ends; var. *ornata* O. Müller, a form with dots more or less regularly arranged in the hyaline area, especially along the raphe; var. *subproducta* V. H., broader and shorter with apices slightly rostrate.

In creeks, ponds, pools, rivers, etc.: Andrews, Anselmo, Arago, Ashland, Auburn, Benkleman, Brock, Broken Bow, Brownlee Callaway, Central City, Chadron, Clear Lake, Cook, Crawford, Culbertson, Dismal River, Fairbury, Grand Island, Hackberry Lake, Halsey, Johnson, Lodi, Louisville, Mason City, Milford, New Helena, North Platte, Northport, O'Neill, Orella, Peru, Roca, St. Paul, Scottsbluff, Seneca, Seward, Sheridan County, Snake River, Stanton, Stromsburg, Talmage, Trenton, Valentine, Weeping Water, West Point, Whitman.

Fossil: Agate, Cherry County, Hay Springs, Merriman, Thedford.

Belvidere, Blackpipe, Cutmeat, Little White River, Rapid City, Rosebud, Scenic, Turtle River, S. Dak.; Devils Lake and fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Rodney, Ohio.

9. **Navicula rangoonensis** (Grun.) Elmore.

*Pinnularia rangoonensis* Grun. in Ms.

Pl. 22, figs. 823–824.

Valves linear with rounded ends, 64–100 μ long, 10–14 μ wide; striations radiate in the middle and converging at the ends, gradually shortened toward the middle, where they are entirely lacking, 9–10 in 10 μ.

In pool, Long Pine.

10. **Navicula parva** (Ehr.) Elmore.

*Stauroptera parva* Ehr. *Verb., p. 135, pl. 3, fig. 19. 1843.*

*Navicula stauroptera* Grun. in *Wien. Verh., p. 516, pl. 2, fig. 18. 1860.*

Pl. 7, figs. 231–246.

Linear or oblong, sometimes elliptical, often slightly swollen in the middle, 36–100 μ long, 7–13 μ wide; apices rounded or slightly swollen; costae radiate in the middle and converging at the ends, 8–12 in 10 μ, shortened, leaving a broad hyaline space along the raphe, becoming shorter toward the center, where they are usually entirely lacking.

Common where conditions for algae are good, in creeks, rivers, lakes, etc.: Alma, Anselmo, Arago, Broken Bow, Brownlee, Clear Lake, Crawford, Crete, Culbertson, Dismal River, Dunning, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Julian, Lincoln, Lodi, Long Pine, Louisville, North Platte, O'Neill, Orleans, Red Cloud, Seneca, Stanton, Talmage, Thedford, Valentine, Weeping Water, West Point.

Fossil: Agate, Loup City, Mullen, Thedford.

Belvidere, Blackpipe, Little White River, Rosebud, S. Dak.; Devils Lake, N. Dak.; Stockton, Cal.

11. **Navicula decurrens** (Ehr.) Kütz. *Bacill., p. 99. 1844.*

*Pinnularia decurrens* Ehr. *Verb., p. 132, pl. 3, f. 5. 1843.*

*Navicula gibba* Ehr. *Abh., 1830, and Inf., p. 184, 1838,* is *Cystopleura gibba* (Ehr.) Kuntze.

*Navicula gibba* Kütz. *Bacill., p. 98, pl. 28, fig. 70. 1844.*

*Pinnularia gibba* Ehr. *Verb., 1843.*

Pl. 7, figs. 247–253.

Linear-elliptic, swollen in the middle and at the ends, the median inflation extending a considerable distance toward the ends, 50–65 μ long, 7–12 μ wide; costae slightly radiating in the center and converging at the ends, usually extending nearly to the raphe, but in the form var. *brevistriata* V. H. very much shortened and sometimes entirely lacking around the central nodule, 9–12 in 10 μ.

In rivers, ponds, etc., among filamentous algae: Clear Lake, Dismal River, Grand Island, Hackberry Lake, Halsey, Seneca, Snake River.
Fossil: Cherry County, Mullen.

12. **Navicula subcapitata** (Greg.) Ralfs in *Pritch. Inf., p. 902. 1845.*
*Pinnularia subcapitata* Greg. in *Mic. Jour., pl. 3, fig. 30. 1856.*
*Navicula hilseana* Janisch according to *Cleve Syn. Nav. Diat., II, p. 175.*
Pl. 8, figs. 254–259.

Linear, sometimes slightly constricted in the middle, with attenuate or capitate apices, 25–50 μ long, 5–9 μ wide; costae 9–18 in 10 μ, slightly radiate toward the middle, converging at the ends, lacking in the center, forming a pseudostauros.

In ponds and creeks: Ainsworth, Clear Lake, Hackberry Lake, Lincoln, Long Pine, Tekamah.
Fossil: Cherry County.
Devils Lake, N. Dak.

13. **Navicula appendiculata** (Ag.) Kütz. *Bacill., p. 93, pl. 3, fig. 28; pl. 4, fig. 2; pl. 5, fig. 5. 1844.*
*Cymbella appendiculata* Ag. *Icon. Alg. Eu., pl. 1. 1828.*
Pl. 8, figs. 260–263.

Linear or slightly lanceolate, often slightly constricted in the middle, 18–44 μ long, 4–8 μ wide; apices more or less rostrate-capitate; costae delicate, radiate in the center, converging at the ends, 13–18 in 10 μ, becoming shorter toward the center, where they are entirely lacking, leaving a pseudostauros. The specimen represented in fig. 262 is elliptical and broader than the type.

In creeks, ponds, tanks, etc.: Brock, Crete, Emerald, Rupert, Stromsburg.
Fossil: Loup City.
Turtle River, S. Dak.

14. **Navicula braunii** Grun. in *V. H. Syn., p. 79, pl. 6, fig. 21. 1885.*
Pl. 8, figs. 264–266.

Lanceolate, slightly swollen in the middle with ends more or less capitate, 35–50 μ long, 8–9 μ wide; costae radiate in the center, converging at the ends, extending nearly to the raphe at the ends, but

gradually shortened toward the center, where they are entirely lacking, leaving a large rectangular hyaline space, 11–12 in 10 μ.

In pools, ditches, etc.: Crete, Long Pine, Talmage.

15. **Navicula mesolepta** Ehr. *Amer., pl. 4, II, fig. 4. 1843.*
*Navicula mesolepta* Kütz. *Bacill., p. 101, pl. 28, fig. 73; pl. 30, fig. 34. 1844.*
Pl. 8, figs. 267–269, 271–272; pl. 22, fig. 837.
Lanceolate, triundulate with capitate ends, 22–62 μ long, 3–12 μ wide; costae radiate near the center, converging at the ends, lacking in the center, leaving a transverse hyaline space, 10–15 in 10 μ. The specimen represented in fig. 268 has shorter costae.

In lakes, creeks, rivers, ponds, etc.: Dunning, Grand Island, Hackberry Lake, Halsey, Lincoln, New Helena, O'Neill, St. Michael, Snake River, Thedford, Trenton, Whitman.
Fossil: Hay Springs, Merriman.
Fresno, Cal.; New Concord, Ohio.

16. **Navicula thermes** (Ehr.) A. Schm. *Atl., pl. 45, figs. 67–71. 1874.*
*Pinnularia thermes* Ehr. *Amer., pl. 2, VI, fig. 22. 1843.*
*Navicula nodulosa* Kütz. *Bacill., p. 101, pl. 3, fig. 57; pl. 28, fig. 71. 1844.*
*Navicula interrupta* W. Sm. *Brit. Diat., I, p. 53,* is a synonym of *N. didyma* Kütz.
Pl. 8, fig. 270; pl. 22, fig. 840.
Linear with parallel or slightly concave margins and capitate ends, 17–76 μ long, 12–13 μ wide; striations radiate near the center and converging at the ends, extending nearly to the raphe at the ends and gradually shortened toward the center, where they are entirely lacking, forming a rhomboidal hyaline space, 9–15 in 10 μ.

In rivers and pools: Ainsworth, Culbertson, Louisville, St. Paul, Thedford.
Fossil: Thedford.

17. **Navicula legumen** Ehr. *Amer., pl. 4, I, fig. 17. 1843.*
Pl. 8, figs. 273–278.
Linear or lanceolate, slightly triundulate, the undulations some-

times faint; apices capitate, 30–80 μ long, 10–16 μ wide; striations radiate in the center, converging at the ends, shortened, leaving a hyaline space along the raphe about one-third the width of the valve, 9–12 in 10 μ.

In springs, creeks, pools: Auburn, Brock, Broken Bow, Dismal River, Emerald, Grand Island, Hackberry Lake, Long Pine, Valentine, West Point.

Fossil: Agate, Cherry County, Loup City, Mullen.

Turtle River, Rosebud, S. Dak.; Cheyenne, Wyo.

18. **Navicula nodosa** Ehr. *Inf., p. 179, pl. XIII, fig. 9(?). 1838.*

Pl. 22, fig. 842.

Valves linear, from strongly triundulate and capitate to nearly straight and rostrate, 55–95 μ long, 9–12 μ wide; raphe fine, curved at the ends; striations 8–10 in 10 μ, slightly radiate at the center and converging at the ends, shortened, extending only a little more than one-fourth of the width of the valve, lacking opposite the central nodule.

In creek, New Helena.

19. **Navicula acrosphaeria** (Breb.) Kütz. *Bacill., p. 97, pl. 5, fig. 11. 1844.*

*Frustulia acrosphaeria* Breb. *Consp. Diat., p. 19. 1838.*

Pl. 8, fig. 279.

Linear, more or less gibbous in the middle, or straight and slightly swollen or constricted at the ends, 18–32 μ long, 7–20 μ wide; costae radiate near the middle and converging at the ends, lacking in the middle, forming a pseudostauros, 9–14 in 10 μ, shortened, leaving an axial area about one-third the width of the valve or extending nearly to the raphe, axial area granular.

Crawford: in pond, Orella.

## II. Radiosae

*A.* Middle striations radiate, terminal converging.
- *b.* Striations fine.
  - *c.* Terminal striations in broken lines. 20. *N. oblonga.*
  - *cc.* Striations in continuous lines.
    - *d.* Middle striations alternately long and short.
      - *e.* Broadly lanceolate.
        - *f.* Not rostrate-capitate.

*g*. More than 30 μ long.
21. *N. peregrina.*
*gg*. Less than 30 μ long.
22. *N. menisculus.*
*ff*. Rostrate-capitate. 23. *N. salinarum.*
*ee*. Narrowly lanceolate. 24. *N. cincta.*
*dd*. Middle striations not alternately long and short.
*c*. Middle striations equally shortened forming a pseudostauros. 25. *N. gracilis.*
*cc*. No pseudostauros.
*f*. Apices not rostrate-capitate.
*g*. Broadly lanceolate, central nodule surrounded by a large hyaline area.
*h*. Apices not rostrate.
26. *N. vulpina.*
*hh*. Apices rostrate.
27. *N. viridula.*
*gg*. Narrowly lanceolate, hyaline area small.
28. *N. radiosa.*
*ggg*. Elliptical-lanceolate.
29. *N. cryptocephala.*
*ff*. Apices rostrate-capitate.
*g*. Hyaline area elongated transversely.
29. *N. cryptocephala.*
*gg*. Hyaline area round.
30. *N. rhynchocephala.*
*bb*. Striations very coarse. 31. *N. hungarica.*

*AA*. Middle striations radiate, terminal perpendicular to the raphe.
*b*. Narrowly lanceolate, hyaline area not stauroneiform.
32. *N. digito-radiata.*
*bb*. Broadly lanceolate, elliptical, or oblong.
*c*. Broadly lanceolate, striations coarse, hyaline area stauroneiform.
33. *N. reinhardtii.*
*cc*. Small with fine striations, hyaline area rounded.
34. *N. minnewaukonensis.*

*AAA*. Striations all radiate.
*b*. Lanceolate to elliptical.
*c*. No pseudostauros. 35. *N. lanceolata.*
*cc*. With pseudostauros.
*d*. Middle striations alternately long and short.
36. *N. gastrum.*
*dd*. Middle striations not alternately long and short.
*c*. Capitate. 37. *N. anglica.*
*cc*. Not capitate. 38. *N. placentula.*
*bb*. Oblong.

| | |
|---|---|
| *c.* Striations finely punctate. | 39. *N. dicèphala.* |
| *cc.* Striations coarsely punctate. | 40. *N. amphibola.* |

20. **Navicula oblonga** Kütz. *Bacill., p. 97, pl. 4, fig. 21. 1844.*
*Frustulia oblonga* Kütz. *Alg. Dec., No. 84. 1834.*
*Navicula macilenta* Ehr. *Inf., p. 183, pl. 21, fig. 13. 1838.*
Pl. 8, figs. 280–282; pl. 22, fig. 843.

Oblong-linear, 92–160 μ long, 14–17 μ wide; margins from center to apices convex or straight, very slightly constricted below the broadly rounded apices; raphe distinct but delicate; striations 6–8 in 10 μ, all radiating at an angle of 45°, except a few at the ends, which are converging, flexuous, those near the ends abruptly broken, shortened opposite the central and terminal nodules, leaving circular areas.

Common among higher algae and also as fossil: Andrews, Anselmo, Benkleman, Big Alkali Lake, Cherry County, Dewey Lake, Dismal River, Dunning, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Lakeside, Long Pine, New Helena, North Platte, Pelican Lake, Rupert, St. Paul, Scottsbluff, Seneca, Thedford, Valentine, Wahoo, Wann, Whitman, Willow Lake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Loup City, Merriman, Mullen, Spalding, Thedford, Valentine, Wheeler County.

Cutmeat, Rosebud, Turtle River, S. Dak.; Court Lake, Devils Lake, Sully's Hill, N. Dak.; Cheyenne, Wyo.

21. **Navicula peregrina** (Ehr.) Kütz. *Bacill., p. 97, pl. 28, fig. 52. 1844.*
*Pinnularia peregrina* Ehr. *Amer., p. 133, pl. I, figs. 5–6. 1843.*
Pl. 8, figs. 283–289.

Elliptical to broadly lanceolate or rhomboidal, sometimes attenuate-rostrate, 34–80 μ long, 8–18 μ wide; striations very distinct, 6–12 in 10 μ, radiate in the center and converging at the ends, extending almost to the raphe, about 3–5 of the middle ones shortened, the alternate ones shorter, leaving a transverse hyaline space.

With higher algae in creeks and ponds: Callaway, Grand Island, Lincoln, Long Pine, North Platte, Red Cloud, Weeping Water.

Rosebud, S. Dak.

22. **Navicula menisculus** Schum. *Preuss. Diat., II, p. 56, pl. 2, fig. 33. 1864.*

Pl. 8, figs. 290–293.

Elliptical-lanceolate, 15–32 μ long, 5.5–13 μ wide, attenuate or attenuate-rostrate; striations radiate, becoming parallel or converging at the ends, 8–15 in 10 μ, closer at the ends than in the middle, the ones in the middle sometimes not much shortened.

In creeks and rivers: Grand Island, Long Pine, Ruby, Seneca.

23. **Navicula salinarum** Grun. *Arct. Diat., p. 33, pl. 2, fig. 34. 1880.*

Pl. 8, figs. 294–295.

Broadly lanceolate with capitate apices, 24–35 μ long, 7–15 μ wide; striations radiate in the middle and converging at the ends, 14–16 in 10 μ, shortened opposite the central nodule, leaving a circular hyaline space.

In pond, Ruby.
Little White River, S. Dak.

24. **Navicula cincta** (Ehr.) Ralfs in *Pritch. Inf., p. 901. 1861.* *Pinnularia cincta* Ehr. *Mikr., pl. 10.2, fig. 6. 1843.*

Pl. 8, figs. 296–298.

Elliptical-lanceolate, 20–40 μ long, 5–7 μ wide, from narrowly to broadly rounded at the apices; striations usually indistinct, about 12 in 10 μ, the middle ones more distant, radiate except at the ends, where they are converging, slightly shortened around the central nodule, leaving a small transverse hyaline space.

Var. *heuflerii* Grun. and var. *leptocephala* Breb. appear to be mere forms.

In fresh and brackish water: Arbor, Fairbury, Grand Island, Long Pine, Louisville, Nebraska City, Nemaha City, Orella, Pawnee City, Peru, Salem, Talmage, Weeping Water.
Devils Lake, N. Dak.

25. **Navicula gracilis** Kütz. *Bacill., p. 91, pl. 3, fig. 48; pl. 30, fig. 57. 1844.*

Pl. 8, figs. 299–303.

Narrowly lanceolate, 38–80 μ long, 8–10 μ wide, apices acute; striations 10–12 in 10 μ, radiate in the center, then straight, and

converging at the ends, those opposite the central nodule equally shortened.

In creeks and rivers: Crawford, Grand Island, Hackberry Lake, Oakdale, Seneca.

26. **Navicula vulpina** Kütz. *Bacill., p. 92, pl. 3, fig. 43. 1844.*
Pl. 22, fig. 825.

Lanceolate, ends obtuse or slightly attenuate, 75–140 μ long, 14–16 μ wide; striations radiate in the center, converging at the ends, shortened opposite the central nodule, leaving a rectangular space, 10–11 in 10 μ.

Fossil in Pliocene stratum: Valentine.
New Concord, Ohio.

27. **Navicula viridula** Kütz. *Bacill., p. 91, pl. 30, fig. 47; pl. 4, figs. 10, 15. 1844.*
Pl. 8, fig. 304.

Broadly lanceolate, 33–70 μ long, 7–10 μ wide, apices tapering, rostrate; striations 8–14 in 10 μ, radiate in the middle, converging at the ends, shortened around the central nodule, leaving a round hyaline space.

In watering trough, Cheyenne, Wyo.

28. **Navicula radiosa** Kütz. *Bacill., p. 91, pl. 4, fig. 23. 1844.*
Pl. 8, figs. 305–311.

Lanceolate, 30–70 μ long, 7–12 μ wide, margin from center to ends convex, straight, or concave, but attenuate at the ends; striations radiate in the middle, slightly curved, converging at the ends, extending nearly to the raphe, but slightly shortened opposite the central nodule, 9–12 in 10 μ. Includes *N. radiosa* var. *acuta* (W. Sm.) Grun.

In creeks and rivers, also fossil: Andrews, Anselmo, Bellevue, Benkleman, Crawford, Culbertson, Dismal River, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Lincoln, Long Pine, Meadow, New Helena, North Platte, Oakdale, Orleans, Red Cloud, St. Michael, St. Paul, Snake River, South Bend, Thedford, Trenton, Valentine, Whitman, Woodlake, Woodlawn.

Fossil: Agate, Greeley County, Loup City, Merriman, Mullen, Valentine, Williams's Canyon.

Belvidere, Blackpipe, Little White River, Rosebud, Turtle River, S. Dak.; Court Lake, fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Emporia, Kansas.

29. **Navicula cryptocephala** Kütz. *Bacill., p. 95, pl. 3, figs. 20–26. 1844.*

Pl. 9, figs. 312–318.

Lanceolate to elliptical, 23–37 μ long, 7–9 μ wide, from slightly or not at all attenuate to rostrate-capitate; striations radiate in the center and converging at the ends, 12–18 in 10 μ. Includes *N. cryptocephala* var. *veneta* (Kütz.) Rabenh.

Very common in creeks, tanks, springs, also fossil: Andrews, Anselmo, Arbor, Ashland, Auburn, Aspinwall, Bellevue, Benkleman, Big Alkali Lake, Brock, Brownlee, Burge, Central City, Clear Lake, Columbus, Crawford, Culbertson, Dawson, Dismal River, Dunning, Durly Lake, Emerald, Emmett, Fairbury, Falls City, Fremont, Grand Island, Hackberry Lake, Haigler, Hemingford, Humboldt, Hyannis, Julian, Lakeside, Lincoln, Little Alkali Lake, Lodi, Long Lake, Long Pine, Louisville, Mason City, New Helena, Newport, Norfolk, North Platte, Omaha, O'Neill, Orella, Orleans, Pawnee City, Peru, Phalaris Lake, Pleasant Dale, Red Cloud, Rulo, Rupert, St. Michael, St. Paul, Scottsbluff, Seneca, Seward, Stanton, Stromsburg, Talmage, Tecumseh, Tekamah, Thedford, Trenton, Valentine, Wahoo, Wann, Weeping Water, West Point, Whitman, Woodlake.

Fossil: Cherry County, Hay Springs, Merriman, Thedford.

Belvidere, Blackpipe, Conata, Imlay, Kadoka, Little White River, Redleaf, Weta, Rosebud, S. Dak.; Court Lake, Devils Lake, fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Stockton, Cal.; Ft. Collins, Colo.; New Concord, Ohio.

30. **Navicula rhynchocephala** Kütz. *Bacill., pl. 30, fig. 35. 1844.* *Navicula rhynchocephala* (Kütz.) W. Sm. *Brit. Diat., I, p. 47. 1853.*

Pl. 9, figs. 320–324.

From broadly lanceolate to linear-elliptical, 23–60 μ long, 7–10 μ wide, varying from attenuate to rostrate-capitate; striations 9–15 in 10 μ, more distant in the center than at the ends, radiate throughout nearly the length of the valve, converging at the ends. Includes *N. rhynchocephala* var. *rostellata.*

In springs and creeks with *Spirogyra* and other algae: Fairbury, Orella. Turtle River, S. Dak.

31. **Navicula hungarica** Grun. in *Wien. Verh., p. 530, pl. 1, fig. 30. 1860.*

*Navicula humilis* Donk. *Brit. Diat., p. 67, pl. 10, fig. 7. 1872.*

Pl. 9, figs. 325–326.

Linear-elliptical, inflated in the middle, 15–20 μ long, 5–6 μ wide; apices rostrate to rostrate-capitate; striations coarse, about 8 in 10 μ, radiate in the center and converging at the ends, extending almost to the raphe.

In rivers, creeks, and ponds, also fossil: Andrews, Cody Lake, Crawford, Fremont, Gordon Creek, Grand Island, Halsey, Lodi, Long Pine, Louisville, New Helena, Norfolk, Pelican Lake, Pleasant Dale, Ruby, Rupert, St. Paul, Seward, Snake River, Stanton, Stromsburg, Valentine, West Point.

Fossil: Cherry County.

Devils Lake, N. Dak.; Rosebud, S. Dak.; Ft. Collins, Colo.; Rio Grande, Ohio.

32. **Navicula digito-radiata** (Greg.) Ralfs in *Pritch. Inf., p. 901. 1861.*

*Pinnularia digito-radiata* Greg. in *Quart. Jour. Mic. Soc., p. 9, pl. 1, fig. 32. 1856.*

Pl. 9, figs. 327–328.

Lanceolate or somewhat oblong, 45–80 μ long, 7–12 μ wide, apices more or less obtuse; striations 8–10 in 10 μ, shortened opposite the central nodule, longer striations alternating with shorter, radiate in the middle, perpendicular to the raphe at the ends.

In rivers: Benkleman, Crawford, Grand Island, Scottsbluff.

Belvidere, Blackpipe, Rapid City, S. Dak.; Blackhand, Muskingum River, New Concord, Ohio.

33. **Navicula reinhardtii** Grun. *Arct. Diat., p. 32. 1880.*

Pl. 9, figs. 329–330; pl. 22, fig. 839.

Oblong, elliptical, or lanceolate, 35–95 μ long, 10–20 μ wide, sometimes attenuated toward the obtusely rounded apices; striations 7–10 in 10 μ, radiate in the middle, becoming perpendicular to the raphe at the ends, shortened, leaving a narrow space along the raphe, 2–4 opposite the central nodule shorter, longer striations alternating with shorter ones, leaving a round central space.

In creeks, also fossil: Fairbury, Gordon Creek, Grand Island, Long Pine.

Fossil: Agate.
Little White River, S. Dak.

34. **Navicula minnewaukonensis** n. sp.

Pl. 9, figs. 331–332.

Broadly lanceolate, oblong, or elliptical, 15–20 $\mu$ long, 4–6 $\mu$ wide; sometimes slightly constricted below the rounded apices; striations 15–16 in 10 $\mu$, all radiating except those at the ends, which are perpendicular to the raphe, those in the center slightly shortened, leaving a very small rounded area.

In sand on shore of Bird Island, Devils Lake, N. Dak.

35. **Navicula lanceolata** Kütz. *Bacill., p. 94, pl. 28, fig. 38; pl. 30, fig. 48. 1844.*

Pl. 9, figs. 333–336; pl. 22, fig. 841.

Lanceolate or sometimes almost elliptical, 30–50 $\mu$ long, 7–11 $\mu$ wide, a form at Stockton, Cal., 15 $\mu$ long, 5.5 $\mu$ wide; apices more or less rostrate; striations 11–12 in 10 $\mu$, closer at the ends than in the middle, shortened around the central nodule, leaving a round hyaline space, all radiate. One specimen found, fig. 333, is 75 x 16 $\mu$ with 9 striations in 10 $\mu$. Sometimes found in the craticulate resting condition as described for *N. cuspidata* and *N. ambigua*. The cells are occasionally found cohering in bands. Fig. 334 and fig. 335 represent a very small form, 13 $\mu$ long.

Very common in pools, creeks, stagnant ditches, tanks, etc., also fossil: Alma, Andrews, Anselmo, Arago, Ashland, Aspinwall, Auburn, Bellevue, Benkleman, Blue Springs, Broken Bow, Cairo, Callaway, Central City, Cedar Creek, Cody Lake, Crawford, Crete, Culbertson, Dawson, Dewey Lake, Dismal River, Dunning, Emerald, Glen Rock, Gordon Creek, Grand Island, Haigler, Halsey, Hastings, Julian, Lincoln, Long Pine, Louisville, Milford, New Helena, Norfolk, North Platte, Oakdale, O'Neill, Orleans, Paul, Pelican Lake, Peru, Pleasant Dale, Red Cloud, Ruby, Rulo, Rupert, St. Libory, St. Michael, St. Paul, Salem, Scottsbluff, Seneca, Seward, Snake River, South Bend, Stanton, Stromsburg, Talmage, Thedford, Trenton, Valentine, Wann, Watts Lake, Weeping Water, West Point.

Fossil: Agate, Cherry County, Loup City.

Court Lake, Devils Lake, N. Dak.; Blackpipe, Cutmeat, Dallas, Interior, Kadoka, Little White River, Rapid City, Redleaf, Rosebud, S. Dak.; Cheyenne, Wyo.; Stockton, Cal.; Ft. Collins, Colo.; Blackhand, New Concord, Rodney, Ohio; Emporia, Kansas.

36. **Navicula gastrum** Ehr. *Amer., p. 133, pl. 3, VII, fig. 23. 1843.*

Pl. 9, figs. 337–338, 344.

Elliptical with apices varying from broadly rounded to capitate, 25–45 μ long, 11–17 μ wide; striations all radiate, 8–11 in 10 μ, those around the central nodule alternately long and short, leaving a round or transversely elongated hyaline space.

In creeks, ponds, and rivers, usually with higher algae, also fossil: Benkleman, Big Alkali Lake, Brownlee, Burge, Central City, Cody Lake, Crawford, Dismal River, Dunning, Gordon Creek, Grand Island, Haigler, Hyannis, Long Pine, Norfolk, North Platte, Phalaris Lake, Red Cloud, St. Paul, Seneca, Stanton, Trenton, Valentine, Wann, Watts Lake, West Point.

Fossil: Agate, Loup City, Merriman.

Cheyenne, Wyo.; Little White River, Rapid City, S Dak.; Devils Lake and fresh water near Devils Lake, N. Dak.; Blackhand, Ohio.

37. **Navicula anglica** Ralfs in *Pritch. Inf., p. 900. 1861.*

Pl. 9, figs. 339–343.

Elliptical with capitate ends, 23–40 μ long, 8–14 μ wide; striations all radiate, 9–15 in 10 μ, shorter around the central nodule, but not alternately longer and shorter. Fig. 342 is a small specimen, 14 μ long, with 20 striations in 10 μ.

Common with other algae in creeks, rivers, ditches, ponds, etc.: Andrews, Anselmo, Ashland, Benkleman, Burge, Cedar Creek, Central City, Cherry County, Clear Lake, Crawford, Dismal River, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Ithaca, Long Pine, Louisville, New Helena, Oakdale, Omaha, Pelican Lake, Red Cloud, St. Paul, Seneca, Snake River, South Bend, Thedford, Valentine, Wann, Willow Lake.

Blackpipe, Little White River, Rosebud, Turtle River, S. Dak.; Devils Lake and fresh water near Devils Lake, N. Dak.; Chippewa Falls, Wis.; Blackhand, Muskingum River, New Concord, Put-in Bay, Rodney, Ohio.

38. **Navicula placentula** (Ehr.) Kütz. *Bacill., p. 94, pl. 28, fig. 57. 1844.*

*Pinnularia placentula* Ehr. *Amer., p. 133, pl. 3, VII, fig. 22. 1843.*

Pl. 9, fig. 345.

Elliptical with apices varying from broadly rounded to capitate, 23–60 μ long, 8–28 μ wide; striations all radiate, 6–10 in 10 μ,

shortened around the central nodule, but not alternately long and short, distinctly punctate, sometimes coarsely so.

Among other algae in creeks, rivers, and ponds, also fossil: Grand Island.

Fossil: Mullen.

Turtle River, S. Dak.

Professor Cleve, *Syn. Nav. Diat., II, p. 23,* says of these three species: "*Navicula placentula* is very nearly akin to *Navicula gastrum*, and it is questionable whether they should not be united into one species. The median striae are in *Navicula gastrum,* but not in *Navicula placentula*, alternately longer and shorter, but this characteristic is subject to great variation, the variety *jenisseyensis* having only a few, and the variety *latiscula* no shorter median striae. Of more importance is it that *Navicula placentula* has coarsely lineate, or almost punctate striae. *Navicula anglica* is nearly akin to *Navicula gastrum* and might be considered a variety of it. There exists, in fact, no limit between these three species. * * * On the other hand, *Navicula placentula* is by its coarsely punctate striae allied to the section *Punctatae,* among which *Navicula amphibola* is nearly akin to *Navicula placentula*. Smaller forms of *Navicula gastrum* closely resemble smaller forms of *Navicula peregrina* var. *menisculus*, from which they differ by the terminal striae being radiate throughout, but this characteristic is sometimes exceedingly delicate."

39. **Navicula dicephala** (Ehr.) Kütz. *Bacill., p. 96, pl. 28, figs. 60, 62. 1844.*

*Pinnularia dicephala* Ehr. *Inf., p. 185. 1838.*

Pl. 9, figs. 346–350.

Linear to linear-lanceolate, with rostrate-capitate ends, 17–40 $\mu$ long, 5–12 $\mu$ wide; striations granular, 8–12 in 10 $\mu$, all radiate, those around the central nodule usually shortened, but not alternately, leaving a transverse hyaline space.

In creeks, lakes, rivers, also fossil: Andrews, Anselmo, Benkleman, Brownlee, Central City, Clear Lake, Cody Lake, Crawford, Dismal River, Dunning, Fairbury, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Holbrook, Long Pine, Louisville, New Helena, Norfolk, Oakdale, O'Neill, Orella, St. Paul, Seneca, Snake River, Thedford, Valentine, Wann, West Point, Whitman.

Fossil: Agate, Cherry County, Hay Springs, Loup City, Merriman, Mullen, Thedford, Valentine, Williams's Canyon.

Little White River, Rapid City, Rosebud, Turtle River, S. Dak.; Cheyenne, Wyo.; Sully's Hill, N. Dak.

40. **Navicula amphibola** Cl. *Diat. of Finl., p. 33, 1891.*

*Navicula punctata asymmetrica* Lagerst. *Diat. of Spetz. 1873.*

*Navicula gastrum styriaca* Grun. *Diat. Oest. und Franz Josef Land.*

Pl. 9, figs. 353–355.

Valves elliptic-lanceolate, 37–70 $\mu$ long, 23–27 $\mu$ wide; apices varying from acuminate to rostrate-capitate; striations radiate, 5–10 in 10 $\mu$, coarsely punctate, puncta 12–15 in 10 $\mu$; striations extending nearly to the raphe, about three of the central ones shortened opposite the central nodule, leaving a transverse space slightly broader outward.

Dismal River, Hackberry Lake, Loup River at Thedford.

Fossil: Agate, Cherry County, Hay Springs, Merriman, Valentine, Williams's Canyon.

### 3. Lyratae

41. **Navicula pygmaea** Kütz. *Spec. Alg., p. 77. 1849.*

Pl. 9, figs. 356–359.

Elliptical, sometimes slightly attenuate at the ends, 20–45 $\mu$ long, 8–12 $\mu$ wide; striations finely punctate, 18–26 in 10 $\mu$, nearly perpendicular in the middle and becoming radiate at the ends, interrupted on each side of the raphe by a sulcus which nearly touches the raphe in the middle and at the ends and is curved outward between these points. Cells often cohering, forming short filaments.

In stagnant or running water with *Oscillatoria,* etc.: Culbertson, Dismal, River, Dunning, Grand Island, Humboldt, Lincoln, New Helena, Norfolk, Pleasant Dale, Rupert, St. Paul, Salem, Seward, Stanton, Stromsburg, Talmage, Trenton, Weeping Water, West Point.

Stockton, Cal.; Devils Lake, N. Dak.

### 4. Stauroneideae

*A.* Striations more distant in center.
  *b.* Elliptical. 42. *N. crucicula.*
  *bb.* Margins undulate. 43. *N. integra.*
*AA.* Striations lacking in the center. 44. *N. rotaeana.*

42. **Navicula crucicula** (W. Sm.) Donkin. *Brit. Diat., p. 44, pl. 6, fig. 14. 1871.*

*Stauroneis crucicula* W. Sm. *Brit. Diat., I, p. 60, pl. 19, fig. 192. 1853.*

Pl. 9, figs. 360–362; pl. 22, fig. 829.

Lanceolate or lanceolate-elliptic with apices obtuse, sometimes attenuate, 26–70 μ long, 8–20 μ wide; striations extending almost to the raphe, slightly or much shortened opposite the central nodule, where they are coarser and slightly more distant than the others, giving the appearance of a stauros, the others radiate, or at the ends transverse, finely punctate, 16–18 in 10 μ.

In salt marsh, Arbor; damp ground, Long Pine.

43. **Navicula integra** (W. Sm.) Ralfs in *Pritch. Infusoria, p. 895. 1861.*

*Pinnularia integra* W. Sm. *Brit. Diat., II, p. 96. 1856.*

Pl. 22, fig. 838.

Elliptical-lanceolate with a constriction near each end, and rostrate-apiculate ends, 23–38 μ long, 8–9 μ wide; striations about 23 in 10 μ, more distant in the middle, reaching nearly to the raphe.

In Prairie Creek, Grand Island.

44. **Navicula rotaeana** (Rabenh.) Cleve. *Nav. Diat., II, p. 128. 1894.*

*Stauroneis rotaeana* Rabenh. *Hedw., I, p. 103, pl. 13, fig. 7. 1852.*

*Stauroneis minutissima* Lagerst. *Spetsb. Diat., p. 39, pl. I, fig. 13. 1873.*

*Stauroneis ovalis* Greg. *M. J., IV, pl. I, fig. 36. 1856.*

*Stauroneis cohnii* Brun. *Diat. des Alpes, p. 91, pl. IX, fig. 10. 1880.*

Pl. 22, fig. 828.

Elliptical, 13–24 μ long, 6–8 μ wide, apices rounded; striations radiate, about 28 in 10 μ, shortened in the center, leaving a pseudostauros which extends nearly to the margins.

In lake in Estes Park, Colo.

5. Palpebrales

45. **Navicula palpebralis** Breb. in *W. Sm. Brit. Diat., I, p. 50, pl. 31, fig. 273. 1853.*

Pl. 9, figs. 363–365.

Elliptic-lanceolate with acute apices, 27–80 μ long, 8–16 μ wide; striations radiate, very short, leaving a lanceolate hyaline space along the raphe, 10–15 in 10 μ. This species is described as marine, but Schönfeldt, *Bacill. Ost. und Schw.*, p. 99, describes a fresh-water form of it.

In creeks, Ithaca, Ruby, St. Paul.

6. Perstriatae

*A.* With coarse puncta. 46. *N. lacustris.*
*AA.* With fine puncta. 47. *N. scutum.*

46. **Navicula lacustris** A. Sch. *N. D., p. 88, pl. 1, fig. 9. 1874.*
*Navicula scandanavica* (Lag.) Cl. *Syn. Nav. Diat., II, p. 48. 1895.*
*Stauroneis scandanavica* Lagerst. *Bohuls. Diat., p. 47. 1876.*

Pl. 9, fig. 366.

Elliptic-lanceolate with apices rostrate, 41–105 μ long, 14–34 μ wide; striations slightly radiate, punctate, extending nearly to the raphe and leaving a very narrow space along it, but shortened opposite the central nodule, leaving a rectangular hyaline space, 12–15 in 10 μ.

In Devils Lake, N. Dak.

47. **Navicula scutum** Schum. in *Königs. Schrift., p. 188, pl. 9, fig. 45. 1863.*

Pl. 9, fig. 367.

Elliptical or lanceolate-elliptical, 30–33 μ long, 10–11 μ wide, apices not attenuate; striations slightly radiate, finely punctate, 16–18 in 10 μ, shortened, leaving a broad irregular hyaline space along the raphe, considerably broader opposite the central nodule.

In creek, Broken Bow; Fremont, Grand Island; pond, Pleasant Dale.

7. Crassinerves

*A.* Apices not capitate.
*b.* Lanceolate.
*c.* Apices rounded, about 11 striations in 10 μ.
48. *N. guatamalensis.*

| | |
|---|---|
| *cc.* Apices acute, about 14 striations in 10 $\mu$. | 49. *N. fulva.* |
| *bb.* Rectangular, apices abruptly pointed. | 50. *N. mucronata.* |
| *AA.* Apices capitate. | 51. *N. ambigua.* |

46. **Navicula guatamalensis** Cl. & Grun. in *Le Diatomiste, II, p. 144, pl. 9, fig. 2.*

Pl. 10, fig. 368.

"Linear-lanceolate, obtuse at the ends, length 115–202 $\mu$, breadth 18–32 $\mu$; median line straight, bordered by a narrow axial area; terminal fissures curved in the same direction; with transverse and longitudinal striations, the transverse parallel, 11 in 10 $\mu$, the longitudinal 23 in 10 $\mu$. Hab. fresh water, Guatamala, fossil." "It is quite near *N. cuspidata* and differs from it in outline and finer striation." Our specimens agree with the description except that in size they are from 124 to 211 $\mu$ long and from 27 to 34 $\mu$ wide with 10 striations in 10 $\mu$.

With *Chara* in Phalaris Lake and at Whitman.

49. **Navicula fulva** (Nitz.) Ehr. *Inf., p. 177, pl. 13, fig. 6. 1838.*
*Bacillaria fulva* Nitz. *Beitr., p. 87, pl. 3, fig. 19. 1817.*
*Navicula cuspidata* Kütz. *Bacill., p. 94, pl. 3, figs. 24, 37. 1844.*

Pl. 10, figs. 369–373, 378–380, 382.

Broadly lanceolate, 31–200 $\mu$ long, apices slightly enlarged or acuminate; striations nearly perpendicular to the raphe, slightly radiate, about 14 in 10 $\mu$, extending nearly to the raphe, leaving a very narrow space which is slightly enlarged opposite the central nodule.

Common in creeks, ponds, tanks, etc.: Ainsworth, Andrews, Arago, Aspinwall, Auburn, Broken Bow, Central City, Cherry County, Clear Lake, Columbus, Culbertson, Dewey Lake, Dismal River, Dunning, Emerald, Emmett, Fremont, Grand Island, Hackberry Lake, Haigler, Halsey, Hemingford, Holt County, Hyannis, Johnson, Julian, Lakeside, Lincoln, Long Lake, Long Pine, Milford, Minden, New Helena, Norfolk, North Platte, O'Neill, Orella, Orleans, Pelican Lake, Peru, Pleasant Dale, Red Cloud, Rupert, Rulo, St. Paul, Seward, Sheridan County, Snake River, Stanton, Stromsburg, Talmage, Thedford, Trenton, Valentine, Wann, Weeping Water, West Point, Whitman.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Merriman, Mullen, Thedford, Valentine, Wheeler County.

Belvidere, Interior, Little White River, Norris, Rosebud, S. Dak.; Court Lake, Devils Lake, fresh water near Devils Lake, N. Dak.; Stockton, Cal.; Ft. Collins, Colo.

50. **Navicula mucronata** n. sp.

Pl. 10, fig. 387.

Rectangular, 40–50 $\mu$ long, 14–16 $\mu$ wide, apices abruptly pointed; striations nearly perpendicular to the raphe, slightly radiate, about 15 in 10 $\mu$, extending nearly to the raphe, leaving a narrow space which is slightly enlarged opposite the central nodule.

In roadside ditch and in Wood River at Grand Island, and in Cody Lake in Cherry County.

51. **Navicula ambigua** Ehr. *Verb., p. 129, pl. 2, fig. 9. 1843.*

Pl. 10, figs. 374–377, 381, 383–386, 388.

Like *N. fulva*, but usually smaller and with rostrate-capitate apices. Van Heurck, *Diat., p. 214*, states that *N. ambigua* is probably only a variety of *N. fulva* (*cuspidata*), but gives it a place as a species. But Schönfeldt, *Diat. Oest. und Schw., p. 76*, makes it only a variety. The two forms occur together with all gradations between them, making it appear as if they were only forms of the same species. But the resting condition described for *N. fulva* occurs also in *N. ambigua*. This condition, as far as observed, occurs only in the typical forms of the two species and never in any of the intermediate forms except possibly in the form represented in fig. 382, and this would indicate that the two species are distinct, for a sporangial condition would not be likely to be found in any but mature forms.

Common in creeks, ponds, tanks, etc.: Alma, Andrews, Anselmo, Ashland, Bellevue, Brock, Broken Bow, Brownville, Central City, Clear Lake, Cody Lake, Columbus, Crawford, Crete, Culbertson, Dismal River, Dunning, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Haigler, Halsey, Hemingford, Holbrook, Humboldt, Johnson, Lakeside, Lincoln, Little Alkali Lake, Louisville, Nebraska City, New Helena, Norfolk, North Platte, Oakdale, Omaha, O'Neill, Orella, Peru, Pleasant Dale, Red Cloud, Rupert, Ruby, St. Michael, St. Paul, Scottsbluff, Seneca, Seward, Sheridan County, Snake River, Stanton, Stromsburg, Talmage, Tecumseh, Tioga, Trenton, Valentine, Wahoo, Wann, Weeping Water, West Point, Whitman.

Fossil: Agate, Cherry County, Greeley County, Merriman, Mullen, Thedford, Valentine.

Belvidere, Blackpipe, Conata, Cutmeat, Interior, Kadoka, Little White River, Norris, Rapid City, Rosebud, Scenic, Weta, S. Dak.; Devils Lake and fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Stockton, Cal.

A form described as *N. cuspidata forma craticula* is found commonly with normal forms. In this condition there are about 4 heavy lines in 10 $\mu$ besides the striations, connecting the thickened margins with the heavy line along the raphe. These specimens are identical in form with ordinary specimens of the species and the arrangement of the endochrome is similar. I have never observed them in motion. On January 13, 1896, I found a specimen in this condition collected in a watering tank at Talmage, Nebraska, on December 26, 1895. The endochrome was diffused through the entire cell. After watching a few minutes the two valves separated, showing a new cell between them with ordinary valves. After the forming of the new cell the old cell contained two vacuoles and part of the endochrome which did not enter into the new diatom. The new diatom was of practically the same size as the old one. In the same collection another diatom had four oil globules in each half of the cell, two large and two small, the larger ones next to the center and the smaller ones at the ends. In this collection there was one specimen of this form to about a dozen in the normal condition. Fig. 382 shows a specimen with 8–9 very radiating striations in 10 $\mu$ in addition to the ordinary striations. De Toni, *Syll. Alg., II, sec. 1, p. 6,* refers to this as an "abnormal state." It has been called *Stictiodesmis craticula* Grev. and *Surirella craticula* Ehr.

### 8. Sculptae

*A.* Apices rostrate or regular; longitudinal sulcus broad.
52. *N. rostrata.*

*AA.* Apices rostrate-capitate; longitudinal sulcus narrow.
53. *N. sphaerophora.*

52. **Navicula rostrata** Ehr. in *Ber., p. 18. 1840.*
*Navicula sculpta* Ehr. *Mikro., pl. 10, I, fig. 5. 1854.*
Pl. 11, figs. 390–397; pl. 22, fig. 835.

Elliptic with apices sometimes tapering, obtuse, 57–114 $\mu$ long, 21–36 $\mu$ wide (one specimen was only 33 $\mu$ long); striations punctate, 12–16 in 10 $\mu$, radiate, interrupted by a longitudinal sulcus, leaving a single row of puncta next to the raphe, the puncta closer near the margin of the valves; also interrupted by a transverse sulcus forming a pseudostauros which usually extends much nearer one margin of the valve than the other. The typical specimens of this species have rostrate apices, but many are regularly elliptic. These elliptic forms seem to belong to *N. polygramma*, a species which Cleve, *Nav. Diat., II, p. 6,* states is a form of *N. sculpta* (*rostrata*). Many of the specimens from Devils Lake have the regularly rhomboidal form shown in fig. 392.

In fresh or brackish water, usually where diatom conditions are good, also fossil: Anselmo, Big Alkali Lake, Clear Lake, Dismal River, Hackberry Lake, Halsey, Lakeside, Little Alkali Lake, North Platte, Orella, St. Paul, Sheridan County, Snake River, Thedford, Valentine, Whitman.

Fossil: Greeley County, Hay Springs, Loup City, Mullen, Spalding, Thedford.

Devils Lake and fresh water near Devils Lake, N. Dak.

53. **Navicula sphaerophora** Kütz. *Bacill., p. 95, pl. 4, fig. 17. 1844.*

Pl. 11, figs. 398–400.

Elliptic- or oblong-lanceolate with rostrate-capitate apices, 32–55 $\mu$ long, 10–20 $\mu$ wide; striations radiate, punctate, interrupted by a longitudinal sulcus which is narrower than in *N. rostrata*, and by a transverse sulcus that forms a pseudostauros, about 16 in 10 $\mu$. Differs from *N. rostrata* in its narrower longitudinal sulcus, capitate apices, and usually smaller size.

In creeks, rivers, etc., usually with other algae, also fossil: Arago, Brock, Broken Bow, Brownlee, Cherry County, Clear Lake, Dismal River, Dunbar, Fremont, Grand Island, Hackberry Lake, Halsey, Humboldt, Julian, Long Pine, New Helena, Peru, Phalaris Lake, Ruby, St. Paul, Salem, Seneca, Sheridan County, Talmage, Valentine, Whitman.

Fossil: Greeley County, Loup City, Mullen, Thedford.

Blackpipe, Rosebud, S. Dak.

### 9. Serianteae

54. **Navicula serians** (Breb.) Kütz. *Bacill., p. 92, pl. 30, fig. 23; pl. 28, fig. 43. 1844.*

*Frustulia serians* Breb. *ex spec.*

Pl. 11, fig. 401; pl. 22, figs. 830–834.

Rhomboid- or oval-lanceolate, 31–80 μ long, 8–15 μ wide, apices acute or slightly rounded; striations slightly radiate, extending nearly to the raphe, about 24 in 10 μ, composed of rows of dots which also form zigzag longitudinal lines.

Lakeside, Thedford.
Fossil: Agate.

10. Formosae

| | |
|---|---|
| Hyaline space slightly enlarged. | 55. *N. liburnica.* |
| Hyaline space much enlarged. | 56. *N. amphisbaena.* |

55. **Navicula liburnica** Grun. *Wien. Verh., 10, p. 547, pl. 1, fig. 25. 1860.*

Pl. 11, figs. 402–403.

Elliptical-lanceolate, 82–100 μ long, 20–25 μ wide; striations radiate, interrupted by a sulcus near the margin, extending nearly to the raphe, slightly shorter opposite the central nodule, leaving an oval hyaline space, 12–16 in 10 μ.

In pool of hot water by old Burlington round house, Lincoln (fig. 402).
Fossil: Agate (fig. 403).

56. **Navicula amphisbaena** Bory. *Encyclop. Method. 1824.*

Pl. 11, fig. 404.

Broadly elliptic, 60–75 μ long, 22–25 μ wide, apices capitate; nodules distinct, the central one slightly lateral; hyaline area very broad, rhomboidal, leaving the striations much shortened; striations radiate, 12–15 in 10 μ, interrupted near the margin by a longitudinal sulcus.

In pool, North Platte; Benkleman.

11. Limosae

| | |
|---|---|
| *A.* With a pseudostauros. | 57. *N. ventricosa.* |
| *AA.* Without pseudostauros. | |
| *b.* With three slight inflations. | 58. *N. silicula.* |
| *bb.* With three large inflations. | 59. *N. trinodis.* |

57. **Navicula ventricosa** Ehr. *Abh., p. 67. 1830.*

Pl. 11, figs. 405–418.

Linear or linear-elliptic, 22–69 μ long, 4–11 μ wide, apices

rounded; striations transverse or slightly radiate, 15–18 in 10 $\mu$, lacking in the center, forming a pseudostauros. Var. *minuta* is probably only a small form of the same.

Among other diatoms, more often in ditches, muddy pools, etc.: Andrews, Brownlee, Callaway, Crete, Dunning, Fremont, Grand Island, Lakeside, Louisville, North Platte, Orella, Pleasant Dale, St. Paul, Scottsbluff, Seneca, Wann, West Point.

Fossil: Loup City.

Cutmeat, Turtle River, S. Dak.; Sully's Hill, N. Dak.; Chippewa Falls, Wis.

58. **Navicula silicula** Ehr. *Amer., p. 131. 1843.*

*Navicula limosa* Kütz. *Bacill., p. 101, pl. 3, fig. 50. 1844.*

Pl. 11, figs. 419–425.

Linear with three slight inflations, 15–85 $\mu$ long, 7–14 $\mu$ wide, apices obtuse, often somewhat apiculate; striations slightly radiate or nearly transverse, interrupted by a narrow sulcus parallel to the margins, not reaching to the raphe and often leaving a hyaline space along it one-third the width of the valve, more shortened opposite the central nodule, leaving a lanceolate or rounded space. Var. *gibberula* (figs. 424–425) is a form with larger inflations and closely connected with *N. trinodis*. Dried valves sometimes iridescent.

In ditches, etc., also fossil: Andrews, Ashland, Benkleman, Brownlee, Central City, Cody Lake, Crawford, Culbertson, Dismal River, Fremont, Gordon Creek, Grand Island, Halsey, Holt County, Lakeside, Lodi, Louisville, Mason City, Norfolk, North Platte, O'Neill, Orella, Pleasant Dale, Polk, Rupert, Ruby, Scottsbluff, Snake River, Stanton, Talmage, Tekamah, Thedford, Trenton, Valentine, Wann, West Point.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Thedford.

Blackpipe, Corn Creek, Rapid City, Redleaf, Rosebud, Turtle River, S. Dak.; fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.

59. **Navicula trinodis** Lewis. *Proceed. Acad. Nat. Sci., Phil., p. 66, pl. II, fig. 6. 1861.*

Pl. 11, figs. 426–428.

Linear with two constrictions making a median and two terminal inflations, 22–57 $\mu$ long, 7–15 $\mu$ wide, median inflation as wide as the terminal or wider, apices from broadly rounded to cuneate or attenuate; striations nearly parallel, tending to be perpendicular to

the margins, about 18 in 10 $\mu$, not reaching to the raphe, leaving a hyaline space along the raphe considerably wider, and rounded opposite the central nodule. Dried specimens usually brownish.

In same locations as *N. silicula:* Alma, Andrews, Arago, Ashland, Auburn, Columbus, Crawford, Crete, Culbertson, Dismal River, Fremont, Gordon Creek, Grand Island, Halsey, Hyannis, Lincoln, Louisville, Milford, North Platte, Oakdale, Pleasant Dale, Rupert, St. Paul, Scottsbluff, Seneca, Stanton, Talmage, Thedford, Trenton, Valentine, Wann, Weeping Water, Whitman, Woodlawn.

Fossil: Loup City, Mullen.

Belvidere, Blackpipe, Corn Creek, Rapid City, Rosebud, S. Dak.; Cheyenne, Wyo.; Ft. Collins, Colo.; Rio Grande, Ohio; Emporia, Kansas.

### 12. Affines

Van Heurck, *Syn., p. 221,* places all of these forms under *N. iridis.* Cleve, *Syn. Nav. Diat., I, p. 67,* states that all of these forms may be varieties of one species. Since there is no definite information as to the life history of the various forms, it seems best in the present work to retain the species as described.

| | |
|---|---|
| *A.* Elongated, 3–6 times as long as wide. | |
| *b.* Margins parallel. | |
| *c.* Ends rounded. | 60. *N. bisulcata.* |
| *cc.* Ends cuneate. | 61. *N. amphigomphus.* |
| *ccc.* Ends rostrate. | 62. *N. affinis.* |
| *bb.* Margins convex, ends rounded or sub-rostrate. | 63. *N. iridis.* |
| *bbb.* Margins undulating. | 62. *N. affinis.* |
| *AA.* Two to three times as long as broad. | 64. *N. dubia.* |

60. **Navicula bisulcata** Lagerst. *Spetz. Diat., p. 31, pl. I, fig. 8. 1873.*

Pl. 12, fig. 429.

Linear, 40–70 $\mu$ long, 8–12 $\mu$ wide, apices rounded; raphe straight, the central ends bent in opposite directions; striations punctate, oblique, about 16 in 10 $\mu$, interrupted near the margin of the valve by a deep sulcus, shortened opposite the central nodule, leaving a transversely elongated hyaline space. Dried valves usually brown.

In creeks, etc.: Andrews, Dunning, St. Paul, Thedford.

Fossil: Agate, Greeley County, Spalding.

61. **Navicula amphigomphus** Ehr. *Verb., p. 129, pl. 3, I, fig. 8. 1845.*

Pl. 12, figs. 430–432.

Broadly linear with cuneate ends, 68–150 μ long, 12–40 μ wide; raphe straight, the central ends bent in opposite directions; striations punctate, oblique, 15–18 in 10 μ, interrupted near the margin of the valve by a deep sulcus, shortened opposite the central nodule, leaving a transverse hyaline space. Dried valves usually brown.

In creeks, ponds, rivers, etc., also fossil: Auburn, Cody Lake, Crawford, Culbertson, Halsey, Lakeside, Norfolk, North Platte, Rupert, Seneca, Stanton, Stromsburg, Trenton, Whitman.

Fossil: Agate, Cherry County, Hay Springs, Loup City, Mullen, Spalding, Thedford, Wheeler County.

62. **Navicula affinis** Ehr. *Amer., p. 129, pl. 2, II, fig. 7. 1843.*

Pl. 12, figs. 433–437.

Linear, margins straight or undulating, 30–60 μ long, 8–15 μ wide, apices rostrate or capitate; raphe straight, the central ends bent in opposite directions; striations punctate, oblique, 16–18 in 10 μ, interrupted near the margin of the valve by a deep sulcus, slightly shortened opposite the central nodule, leaving a small rounded hyaline space. Dried valves usually brown.

In creeks, ponds, rivers, etc., also fossil: Andrews, Auburn, Blue Springs, Dismal River, Fremont, Grand Island, Hackberry Lake, Long Pine, New Helena, Talmage, Thedford, Valentine.

Fossil: Agate, Loup City, Mullen, Wheeler County.

Blackpipe, Rapid City, Rosebud, S. Dak.

63. **Navicula iridis** Ehr. *Amer., p. 130, pl. 4, I, figs. 1–2. 1843.*

Pl. 12, figs. 438–439.

Linear to elliptic, 26–170 μ long, 5–30 μ wide, apices rounded or somewhat attenuate; raphe straight, the central ends bent in opposite directions; striations granular, oblique, 15–17 in 10 μ, interrupted near the margin of the valve by a deep sulcus, shortened opposite the central nodule, leaving a transverse hyaline space. Dried valves usually brown.

In creeks, rivers, ponds, etc., also fossil: Andrews, Anselmo, Ashland, Atkinson, Auburn, Clear Lake, Culbertson, Dismal River, Dunning, Gor-

don Creek, Grand Island, Hackberry Lake, Halsey, Hemingford, Long Pine, Oakdale, Pelican Lake, Red Cloud, St. Paul, Seneca, Snake River, Thedford, Valentine, Wann, Whitman.

Fossil: Agate, Greeley County, Hay Springs, Loup City.

Belvidere, Little White River, Scenic, S. Dak.; Court Lake, N. Dak.; Stockton, Cal.

64. **Navicula dubia** Ehr. *Amer., p. 130, pl. II, 2, fig. 8. 1843.*

Pl. 12, fig. 440.

Elliptical, sometimes slightly biconstricted, 27–37 $\mu$ long, 10–12 $\mu$ wide; raphe straight, the central ends bent in opposite directions; striations punctate, oblique, 16–24 in 10 $\mu$, interrupted near the margin of the valve by a deep sulcus, scarcely shortened opposite the central nodule. Dried valves usually brown.

Pool, Crete.

### 13. Bacilleae

*A.* Linear, terminal nodules not expanded laterally. 65. *N. bacilliformis.*
*AA.* Swollen in the middle; terminal nodules expanded laterally. 66. *N. pupula.*

65. **Navicula bacilliformis** Grun. in *Cl. & Grun. Arct. Diat., p. 44, pl. 2, fig. 51. 1880.*

Pl. 12, figs. 441–442; pl. 22, fig. 836.

Linear with broad rounded ends, sometimes slightly gibbous at the ends and in the middle, 30–45 $\mu$ long, 7–10 $\mu$ wide; striations slightly radiate, usually slightly converging at the ends, 12–16 in 10 $\mu$, shortened opposite the central nodule, leaving a rectangular hyaline space about one-half the width of the valve.

In lakes, creeks, rivers, etc., also fossil: Ashland, Central City, Clear Lake, Columbus, Crete, Dunning, Fremont, Grand Island, Hackberry Lake, Hemingford, Long Pine, Louisville, O'Neill, Oakdale, St. Paul, Sheridan County, Stanton, Talmage, Thedford, Whitman.

Fossil: Loup City, Greeley County, Hay Springs, Merriman, Mullen.

Belvidere, Rosebud, S. Dak.; fresh water near Devils Lake, N. Dak.

66. **Navicula pupula** Kütz. *Bacill., p. 93, pl. 30, fig. 40. 1844.*

Pl. 12, figs. 443–447.

Linear, usually swollen in the middle and at the ends, 19–37 $\mu$ long, 7–9 $\mu$ wide, apices broadly rounded or nearly truncate; striations radiate, 18–23 in 10 $\mu$, shortened opposite the central nodule.

leaving a rectangular hyaline space about one-half the width of the valve or sometimes extending across the entire width of the valve; terminal nodules expanded laterally. Cells often cohering in filaments.

In creeks, rivers, ponds, etc., especially with green algae, also fossil: Alma, Andrews, Ashland, Benkleman, Broken Bow, Brownlee, Burge, Clear Lake, Crawford, Culbertson, Dewey Lake, Dismal River, Dunning, Fairbury, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Lakeside, Long Pine, Louisville, Nebraska City, Norfolk, New Helena, North Platte, Oakdale, Orella, Orleans, Pleasant Dale, Red Cloud, Ruby, Rupert, St. Paul, St. Michael, Seneca, Seward, Snake River, Stanton, Stromsburg, Talmage, Thedford, Trenton, Valentine, Wann, West Point.

Fossil: Agate, Greeley County, Hay Springs, Loup City, Merriman, Spalding.

Little White River, S. Dak.; Stockton, Cal.

### 14. Minutissimae

*A.* Valves lanceolate. 67. *N. cocconeiformis.*
*AA.* Valves elliptical, very small.
*b.* Striations very fine. 68. *N. atomoides.*
*bb.* Striations coarser. 69. *N. mutica.*

67. **Navicula cocconeiformis** Greg. in *Quart. Jour. Mic. Soc., IV, p. 6, pl. 1, fig. 22. 1856.*

Pl. 12, fig. 448.

Elliptical or lanceolate, sometimes slightly swollen in the middle, 26–48 $\mu$ long, 9–13 $\mu$ wide; apices rounded or obtuse; striations slightly radiate, granular, those opposite the central nodule of unequal length, about 18 in 10 $\mu$ in the middle, 28–30 in 10 $\mu$ at the ends.

In creek, Humboldt.

68. **Navicula atomoides** Grun. in *V. H. Syn., p. 107, pl. 14, fig. 11. 1885.*

*Navicula minima* var. *atomoides* Cl. *Syn. Nav. Diat., II, p. 128. 1894.*

Pl. 12, figs. 449–450.

Elliptical or linear-elliptical, 8–12 $\mu$ long, 2.7–3 $\mu$ wide, ends rounded; striations slightly radiate, 27–30 in 10 $\mu$, shortened opposite the central nodule, leaving a pseudostauros. Cells often united in bands of 3 or 4.

In tanks, etc.: Dunning, Grand Island, Hastings, Stromsburg. Fresno, Cal.

69. **Navicula mutica** Kütz. *Bacill., p. 93, pl. 3, fig. 32. 1844.*

Pl. 12, figs. 451–452.

Valves elliptical or elliptic-lanceolate, margins sometimes undulating, 13–33 μ long, 7–11 μ wide; striations radiate, 18–20 in 10 μ, several opposite the central nodule shortened, leaving a pseudostauros.

In rivers: Benkleman, Haigler, Long Pine, Orleans, West Point. Fresno, Cal.

## 20. Scoliopleura

**Scoliopleura** Grun. in *Wien. Verh., X, p. 554. 1860.*

Etym. from Gr. σκολιός, twisted, and πλευρά, side, referring to the form of the valve.

Like *Navicula*, but faces of the valves convex, spirally twisted, making the raphe and connecting zone sigmoid.

*A.* Large with coarse striations. 1. *S. tumida.*
*AA.* Smaller with finer striations. 2. *S. peisonis.*

1. **Scoliopleura tumida** (Breb.) Rabenh. *Fl. Eu. Alg., p. 229. 1864.*

*Navicula tumida* Breb. in *Kütz. Spec. Alg., p. 77. 1849.*

Pl. 13, figs. 472–473.

Lanceolate, 100–160 μ long, 20–25 μ wide (one specimen found was only 37 μ long); striations nearly perpendicular to the margins, extending nearly to the raphe, leaving a very narrow axial area, the central striations shortened, leaving an irregular space around the central nodule; cells twisted spirally, making the raphe slightly sigmoid; faces of the valves convex.

Fossil: Agate.

2. **Scoliopleura peisonis** Grun. *Verh., p. 554, pl. 3, fig. 25. 1860.*

Pl. 13, fig. 474.

Elliptical with rounded apices, 35–80 μ long, 10–18 μ wide; raphe sigmoid, enclosed between two longitudinal ridges which are at the ends of the striations; striations transverse, punctate, 12–16 in 10 μ.

In Devils Lake, N. Dak.

## 21. Stauroneis

**Stauroneis** Ehr. *Amer., p. 134. 1843.*

Etym. from Gr. σταυρός, cross, the transverse central nodule forming with the *rachis*, a cross.

Cells as in *Navicula*, but the central nodule broadened transversely into a "stauros" (cross). Frequently also with a transverse hyaline area bordering the stauros. Girdle with or without interzones; free or in a gelatinous envelope. Chromatophores as in *Navicula*. Auxospores single from two mother cells.

*A*. Margins not undulate.
  *b*. Apices not attenuate-rostrate.
    *c*. Cells without a lumen. — 1. *S. phoenicenteron.*
    *cc*. Cells with a lumen. — 2. *S. acuta.*
  *bb*. Apices attenuate-rostrate.
    *c*. Cells very small. — 3. *S. parvula.*
    *cc*. Cells of medium size. — 4. *S. anceps.*
*AA*. Margins undulate.
  *b*. Apices apiculate. — 5. *S. linearis.*
  *bb*. Apices rounded. — 6. *S. legumen.*

1. **Stauroneis phoenicenteron** Ehr. *Verb., pl. II, 5, fig. 1. 1843.*
*Bacillaria phoenicenteron* Nitz. *Beitr., pl. 3, figs. 12, 14. 1817.*
Pl. 12, figs. 453–455, 457–459.

Lanceolate, slightly attenuate, 62–266 μ long, 13–40 μ wide; apices obtuse, rounded, often slightly constricted; raphe consisting of a double line for the greater part of its length; stauros broad, extending to the margins of the valve, usually slightly dilated outward; striations granular, radiate, 14–18 in 10 μ, shortened, leaving a broad hyaline space along the raphe. A sporangial condition is shown in fig. 456.

In creeks, rivers, ponds, ditches, springs, tanks, etc., usually with other algae, also fossil: Andrews, Anselmo, Ashland, Atkinson, Broken Bow, Central City, Cherry County, Clear Lake, Crawford, Dismal River, Dunning, Grand Island, Hackberry Lake, Hemingford, Johnson, Lincoln, Lodi, Louisville, New Helena, North Platte, Oakdale, Orella, Pelican Lake, Peru, Plattsmouth, Ruby, St. Paul, St. Michael, Seneca, Snake River, Talmage, Tekamah, Thedford, Valentine, Wahoo, Wann.

Fossil: Cherry County, Greeley County, Loup City, Mullen, Valentine.

Rapid City, Rosebud, S. Dak.; Cheyenne, Wyo.; Sully's Hill, N. Dak.; New Concord, Rio Grande, Ohio.

2. **Stauroneis acuta** W. Sm. *Brit. Diat., I, p. 59, pl. 19, fig. 187. 1853.*

Pl. 12, figs. 456, 460.

Rhombic-lanceolate or gradually tapering from the middle to the narrow obtuse ends, or elliptical, 80–150 $\mu$ long, 15–40 $\mu$ wide; margins thickened at the ends, leaving a distinct diaphragm or lumen; raphe double for most of its length; stauros very broad, wider at the margins of the valve; striations granular, radiate, about 12 in 10 $\mu$; cells usually united in short bands.

In spring, Brock; Dewey Lake, Hackberry Lake.

3. **Stauroneis parvula** Janisch. *Guano, p. 14. 1861.*

Pl. 12, figs. 461–462.

Linear-lanceolate or oblong, 12–25 $\mu$ long, 5–6 $\mu$ wide; apices more or less rostrate; stauros extending to the margins; striations radiate, granular, extending nearly to the raphe, 20–23 in 10 $\mu$.

In creek, Anselmo; in bottle in laboratory, Grand Island; St. Paul, Valentine.

Fossil: Agate.

Rosebud, S. Dak.

4. **Stauroneis anceps** Ehr. *Amer., p. 134, pl. 2, I, fig. 18. 1843.*

Pl. 12, figs. 463–468.

Elliptical or elliptical-lanceolate with apices varying from rostrate to rostrate-capitate, 27–130 $\mu$ long, 6–17 $\mu$ wide; stauros broad, usually extending to the margins of the valve, slightly broader outward; striations radiate, granular, 14–20 in 10 $\mu$, shortened, leaving a hyaline space along the raphe. Var. *amphicephala*, fig. 466, is more linear in form with capitate apices. Var. *linearis*, fig. 465, has rostrate apices. This species shows all gradations into *S. phoenicenteron*.

In pools, tanks, creeks, springs, etc., also fossil: Ainsworth, Andrews, Ashland, Auburn, Brock, Central City, Clear Lake, Columbus, Dismal River, Dunning, Emmett, Fairbury, Grand Island, Hackberry Lake, Halsey, Hemingford, Hyannis, Julian, Lincoln, Long Pine, Louisville, Milford, New Helena, Norfolk, Omaha, O'Neill, Orella, Peru, Red Cloud, St. Paul, Snake River, Talmage, Valentine, Wann, Weeping Water, West Point, Woodlake.

Fossil: Cherry County, Loup City, Merriman, Mullen.

Belvidere, Interior, Little White River, Rapid City, Rosebud, S. Dak.; Cheyenne, Wyo.; Stockton, Cal.; New Concord, Rio Grande, Ohio.

5. **Stauroneis linearis** Ehr. *Amer., p. 135, pl. 1, fig. II, 11. 1843.*

*Stauroneis smithii* Grun. *Wien. Verh., p. 464, pl. VI, fig. 16. 1860.*

Pl. 12, fig. 469.

Oblong or lanceolate, 20–30 $\mu$ long, 7–8 $\mu$ wide, triundulate with middle inflation larger; stauros narrow, slightly wider at the extremities; apices apiculate; striations slightly radiate, about 30 in 10 $\mu$; cells united in short bands.

In creeks, rivers, etc.: Arago, Dewey Lake, Dunning, Grand Island, Long Pine, Mason City, Tekamah, Thedford, Wahoo, Wann.
Fossil: Agate, Merriman.
Blackpipe, Rapid City, Rosebud, Turtle River, S. Dak.; Fresno, Cal.

6. **Stauroneis legumen** Ehr. *Abh., p. 135, pl. I, 2, fig. 5. 1844.*

Pl. 12, figs. 470–471.

Linear, triundulate, 21–35 $\mu$ long, 4.5–8 $\mu$ wide; apices rostrate-capitate; striations radiate, 27–30 in 10 $\mu$; stauros reaching nearly to the margins, not dilated outward; cells united in short bands.

Gordon Creek, Red Cloud.
Fossil: Cherry County.

## 22. Diploneis

**Diploneis** Ehr. *1840.*

Usually short, constricted in the middle or not, usually with obtuse or rounded ends; fresh-water species elliptical; central nodule more or less quadrate, prolonged into horns or processes which lie parallel to the raphe. On both sides of the horns are depressions or furrows of more or less breadth. General structure like *Navicula,* except that the central nodule is prolonged.

**Diploneis elliptica** (Kütz.) Cl. *Syn. Nav. Diat., I, p. 92. 1894.*
*Navicula elliptica* Kütz. *Bacill., p. 98, pl. 30, fig. 55. 1844.*

Pl. 13, figs. 475–482.

Oval-elliptic or oblong-elliptic, 12–55 $\mu$ long, 7–22 $\mu$ wide; raphe heavy, central nodule quadrangular with horns slightly curved; striations composed of puncta, 7–15 in 10 $\mu$, nearly perpendicular to the margin of the valve. The forms called var. *oblongella* and var. *minima* are found.

In creeks, rivers, ponds, etc., among higher algae, also fossil: Benkleman, Brownlee, Burge, Central City, Crawford, Culbertson, Dismal River, Dunning, Johnson, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Holt County, Hyannis, Lincoln, Long Pine, Louisville, New Helena, North Platte, Omaha, St. Paul, Scottsbluff, Seneca, Stanton, Stromsburg, Tekamah, Trenton, Valentine, Wann.

Fossil: Agate, Loup City, Merriman, Spalding, Valentine.

Little White River, Weta, S. Dak.; Stockton, Cal.; Ft. Collins, Colo.

### 23. Achnanthes

**Achnanthes** Bory. *Dict. Class., I, p. 79, 593. 1822.*

Etym. from Gr. ἄχνη, point, and ἄνθος, flower.

Cells single or forming short chains attached by the basal cell, cells curved in girdle view; valves elliptical to lanceolate, often broader or narrower in the middle; valves dissimilar, the one concave with a true raphe and central and terminal nodules, the other convex with a pseudoraphe; both valves striate with transverse rows of dots, sometimes ribbed.

*A.* Lower valve with a pseudostauros. 1. *A. hungarica.*
*AA.* Lower valve without a pseudostauros.
  *b.* Upper valve differing from the lower only in the absence of raphe and nodules.
    *c.* Apices capitate.
      *d.* Narrowly lanceolate. 2. *A. microcephala.*
      *dd.* Gibbous in the middle. 3. *A. biasolettiana.*
    *cc.* Apices not capitate. 4. *A. linearis.*
  *bb.* Upper valve with a borseshoe-shaped hyaline space next to one margin in the middle. 5. *A. lanceolata.*

1. **Achnanthes hungarica** Grun. in *Cl. & Grun. Arct. Diat., p. 20. 1880.*

Pl. 13, figs. 483–487; pl. 23, fig. 844.

Narrowly elliptic or linear-lanceolate with ends more or less cuneate or rounded, 15–43 μ long, 6–8 μ wide; upper valve with a narrow axial area, the two middle striations shortened; lower valve with raphe along which is a narrow hyaline space, central striations lacking, leaving a pseudostauros; striations slightly radiate, 18–21 in 10 μ; cells geniculate or, when in longer chains, nearly straight, as in fig. 844.

In creeks, rivers, ditches, ponds, etc., also fossil: Anselmo, Broken

Bow, Brownlee, Cairo, Callaway, Central City, Cody Lake, Columbus, Crawford, Dismal River, Dunning, Emerald, Grand Island, Hackberry Lake, Halsey, Lodi, Louisville, Orella, Pelican Lake, Pleasant Dale, Roca, Ruby, St. Paul, Scottsbluff, Seneca, Stanton, Tekamah, Thedford, Trenton, Valentine.

Fossil: Agate, Cherry County, Mullen, Valentine.

Norris, Rapid City, Rosebud, S. Dak.; Stockton, Cal.

2. **Achnanthes microcephala** (Kütz.) Grun. in *Cl. & Grun. Arct. Diat., p. 22. 1880.*

*Achnanthidium microcephalum* Kütz. *Bacill., p. 75, pl. 3, figs. 13, 19. 1844.*

Pl. 13, figs. 488–489.

Narrowly lanceolate, 9–26 $\mu$ long, 3–4 $\mu$ wide; apices capitate; upper valve with parallel striations, all extending to the pseudoraphe except the middle ones, 30–36 in 10 $\mu$; striations of the lower valve slightly radiate, those in the middle much shortened, leaving a transverse hyaline space; cells geniculate, often united in bands.

In creeks, rivers, tanks, etc., also fossil: Andrews, Burge, Grand Island, Hemingford, Long Pine, Scottsbluff, Woodlake.

Fossil: Agate.

Cheyenne, Wyo.; Blackpipe, S. Dak.; Devils Lake, N. Dak.; Fresno, Stockton, Cal.; Emporia, Kansas.

3. **Achnanthes biasolettiana** (Kütz.) Grun. *Arct. Diat., p. 22. 1880.*

*Synedra biasolettiana* Kütz. *Bacill., p. 63, pl. 3, fig. 22. 1844.*

Pl. 13, figs. 490–491.

Broadly lanceolate, more or less swollen in the middle, 10–20 $\mu$ long, 4–6 $\mu$ wide; apices broad, rounded, sometimes slightly capitate; striations slightly radiate, 20–25 in 10 $\mu$. Cleve, *Syn. Nav. Diat., II, p. 189*, gives the length 55–31 $\mu$, in which he is followed by Schönfeldt, *Diat. Deutsch., Oest., und Schw., p. 55.* It is likely that Cleve's measurement was intended to be 5.5–31 $\mu$. Van Heurck, *Diat., p. 281*, gives the length about 10 $\mu$, which agrees with both his and Schönfeldt's figures and with the specimens found in Nebraska.

Fossil: Agate.

4. **Achnanthes linearis** (W. Sm.) Grun. *Arct. Diat., p. 23. 1880.*

*Achnanthidium lineare* W. Sm. *Brit. Diat., II, p. 31, pl. 61, fig. 381. 1856.*

Pl. 13, figs. 492–493.

Linear with rounded ends, 10–20 $\mu$ long, 3–4 $\mu$ wide; upper valve with narrow, linear axial area and parallel striations; lower valve without axial area and with small transverse central area; striations radiate, 22–28 in 10 $\mu$; cells geniculate.

In Seven Springs at Long Pine.

5. **Achnanthes lanceolata** (Breb.) Grun. *Arct. Diat., p. 23. 1880.*

*Achnanthidium lanceolatum* Breb. in *Kütz. Spec. Alg., p. 54. 1849.*

Pl. 13, figs. 494–499.

Narrowly elliptic-lanceolate to broadly elliptical, 11–35 $\mu$ long, 4–8 $\mu$ wide; upper valve with linear central axial area broadened on one side in the middle into a broad horseshoe-shaped hyaline area; striations granular, nearly parallel, 12–16 in 10 $\mu$; lower valve with narrow axial area and broad rectangular central area; striations granular, slightly radiate; cells geniculate.

In creeks, tanks, ponds, lakes, etc.: Andrews, Ashland, Burge, Clear Lake, Dismal River, Dunning, Gordon Creek, Grand Island, Halsey, Long Pine, Louisville, Mason City, Milford, O'Neill, Orella, Orleans, Pleasant Dale, Polk, Red Cloud, Snake River, Tekamah, Thedford, Valentine, Wann, Watts Lake.

Stockton, Cal.; Court Lake, Sully's Hill, N. Dak.; Blackhand, Granville, Ohio.

## 24. Cocconeis

**Cocconeis** Ehr. *Inf., p. 193. 1835. em. Grun. Alg. Nov., p. 11. 1868.*

*Actinoneis* Cleve; *Heteroneis* Cleve.

Etym., from Gr. κόκκος, berry, or grain, on account of its resemblance to a grain of wheat.

Cells single, straight or curved in girdle view and the plane of the upper valve with its margins turned downward; valves round-elliptical to circular, dissimilar, the lower concave with a true raphe

and nodules, the upper with pseudoraphe and no nodules, both transversely punctate-striate; interzones with a narrow marginal fenestrated septum or none; cells living in masses beside but not upon one another, usually epiphytic on other algae. One auxospore is formed asexually from a single cell. The following descriptions of species are taken mostly from Schönfeldt, *Diat. Deutsch., Oest., und Schw.*

*A.* With a narrow hyaline space in the middle of the valve.
*b.* With a distinct marginal ring on lower valve. 1. *C. placentula.*
*bb.* Without distinct marginal ring on lower valve. 2. *C. pediculus.*
*AA.* With wide hyaline space in the middle of the valve. 3. *C. disculus.*

1. **Cocconeis placentula** Ehr. *Inf., p. 194. 1838.*
Pl. 13, figs. 500–504.

More or less broadly elliptic; upper valve with narrow pseudoraphe, lower valve with distinct raphe not reaching to the ends; striations of the upper valve finely granular, the granules forming undulating longitudinal lines, striations extending to the margins of the valve; lower valve with a distinct broad marginal ring marked with fine granules, striations extending to the marginal ring; length 12–35 $\mu$, width 8–20 $\mu$, striations 15–25 in 10 $\mu$.

Epiphytic on filamentous algae: Andrews, Bellevue, Broken Bow, Callaway, Cedar Creek, Cherry County, Clear Lake, Crawford, Dewey Lake, Dismal River, Dunning, Emmett, Fremont, Grand Island, Hackberry Lake, Holt County, Hyannis, Lodi, Long Lake, Long Pine, New Helena, Newport, Oakdale, Omaha, Pelican Lake, Red Cloud, St. Paul, St. Michael, Scottsbluff, Seneca, Snake River, South Bend, Thedford, Trenton, Valentine, Watts Lake, Whitman, Willow Lake.

Fossil: Greeley County, Hay Springs, Loup City, Merriman, Valentine Belvidere, S. Dak.; Fresno, Cal.; Ft. Collins, Colo.; New Concord, Ohio.

Var. *intermedia* has very coarsely punctate striations on the upper valve, 8–12 in 10 $\mu$.

In river at Seneca.

2. **Cocconeis pediculus** Ehr. *Inf., p. 194, pl. 21, fig. 11. 1838.*
Pl. 13, figs. 505–507.

Elliptical but in form and size extremely variable, long- or broad-elliptical or almost rectangular with rounded corners, some-

times one or both margins bent in at the ends, abnormal forms also occurring; upper surface arched, upper valve with narrow pseudoraphe, lower valve with fine but distinct raphe, distinct terminal and central nodules; striations of the upper valve finely granular, on the margin in the middle often united in twos, slightly radiate, granules of the striations irregular, giving with oblique illumination an undulating appearance; lower valve with narrow area along the raphe, somewhat wider at the central nodule; striations extending almost to the margins of the valve, leaving only a narrow structureless marginal ring; length 15–30 $\mu$, breadth 10–20 $\mu$, striations 17–18 in 10 $\mu$.

*C. placentula* var. *lineata* Ehr., *Amer., p. 81,* is larger and with striations on the upper valve forming zigzag longitudinal lines. Fig. 506, Valentine, Dewey Lake.

Epiphytic on filamentous algae, very common: Andrews, Ashland, Benkleman, Broken Bow, Burge, Central City, Cody Lake, Columbus, Culbertson, Dewey Lake, Dismal River, Dunning, Fairbury, Fremont, Grand Island, Hackberry Lake, Halsey, Hyannis, Lakeside, Lodi, Long Pine, Louisville, Norfolk, North Platte, Northport, Orleans, Pelican Lake, Ruby, Rupert, St. Paul, Seneca, Stanton, Tioga, Trenton, Valentine, West Point, Wann, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Thedford. Cheyenne, Wyo.; Court Lake, Devils Lake, and fresh water near Devils Lake, N. Dak.; Belvidere, Blackpipe, Little White River, Norris, Rapid City, S. Dak.; Muskingum River, pond on island in Lake Erie, Ohio.

3. **Cocconeis disculus** (Schum.) Cl. in *Cl. & Jentzsch Alluv. Diat. Norddeutsch., p. 129. 1882.*

*Navicula disculus* Schum. *Preuss. Diat., p. 21, pl. 2, fig. 23. 1864.*

Pl. 13, fig. 508.

Broadly elliptical, 11–20 $\mu$ long, 9–15 $\mu$ wide; striations 8–13 in 10 $\mu$, composed of coarse dots, shortened, leaving a lanceolate hyaline space; lower valve with very delicate, scarcely visible raphe; striations radiate, consisting of 3 or 4 heavy elongated dots.

In Loup River near Lodi.

## 25. **Brebissonia** (*Vanheurckia, Frustulia*)

**Brebissonia** Grun. in *Wien. Verh., p. 512. 1860.*
*Vanheurckia* Breb. *Ess. Monog. sur le Vanheurckia. 1868.*
*Frustulia* Grun. *Desm. Diat. Ins. Banka, p. 10. 1865.*
(Not *Frustulia* Ag. *Syst. Alg., p. XIII, 1, 1824.*)
Etym., named for Brebisson.

Cells like *Navicula,* free or very rarely enclosed in gelatinous tubes; striations fine, parallel or slightly radiate in the middle of the valve; raphe enclosed between two siliceous ribs; terminal and central nodules more or less elongated. Striations composed of dots arranged in transverse and longitudinal rows. Chromatophores two plates lying next to the girdle, not changing their position in the cell before division. Auxospore formation; two cells arrange themselves parallel to each other in a mucous mass and form after casting off their shells two cylindrical, transversely striated auxospores which lie parallel to the old valves, the ends of the auxospores forming caps which are later thrown off; valves of the daughter cells formed within the perizonium.

*A.* Elliptic-lanceolate, central striations radiate. 1. *B. vulgaris.*
*AA.* Linear-lanceolate, all striations perpendicular 2. *B. interposita.*

1. **Brebissonia vulgaris** (Thwait.) Kuntze. *Rev. Gen. Plant., III, 2, p. 398. 1900.*
*Collectonema vulgare* Thwait. in *Ann. Nat. Hist., ser. 2, Vol. I, pl. 12.*
*Vanheurckia vulgaris* (Thwait.) V. H. *Diat., p. 240. 1896.*
Pl. 13, fig. 509.

Elliptical-lanceolate, 44–70 $\mu$ long, 11–15 $\mu$ wide, apices obtuse, slightly attenuate, central nodule elongated; striations fine, more distant in the center, 24–34 in 10 $\mu$, slightly radiate in the center, nearly perpendicular to the raphe at the ends; cells enclosed in unbranched gelatinous tubes.

In springs, creeks, etc., and on muddy ground: Brock, Dewey Lake, Grand Island, Julian, Lincoln, Mason City, Peru, Seward, Talmage, Tekamah.
Blackhand, Rodney, Ohio.

2. **Brebissonia interposita** (Lewis) Kuntze. *Rev. Gen. Plant., III, 2, p. 398. 1900.*

*Navicula interposita* Lewis. *Proc. Acad. Phil., p. 15, pl. 2, fig. 19. 1865.*

*Frustulia interposita* (Lewis) Cl. *Syn. Nav. Diat., I, p. 123. 1894.*

Pl. 13, figs. 510–511.

Linear-elliptical, 82–130 $\mu$ long, 12–27 $\mu$ wide, apices rounded; central nodule elongated, terminal nodules round, close to the ends; transverse striations 20–24 in 10 $\mu$, perpendicular to the raphe, longitudinal striations about 18 in 10 $\mu$.

Fossil: Agate.

## 26. **Gyrosigma** (*Pleurosigma*)

**Gyrosigma** Hass. *Brit. Freshw. Alg., p. 435. 1845.*

*Pleurosigma* W. Sm. in *Ann. Nat. Hist., II, Vol. 9, p. 5. 1853; Achnanthosigma* Reinh.; *Endosigma* Breb.; *Scalprum* Corda; *Staurosigma* Grun.

Etym., from Gr. γῦρος, curve, and σίγμα, the letter *s*, in allusion to the curved form of the cells.

Cells single, free or rarely enclosed in gelatinous tubes; straight and oval-linear in girdle view, sigmoid in valve view; valves bilaterally symmetrical, sigmoid-lanceolate; raphe median, sigmoid; central nodule small; striations crossing in three directions (decussate), or at right angles (rectangular), reaching almost to the raphe. Chromatophores two large widely overlapping plates lying next to the girdle.

*A.* Striations running in three directions. 1. *G. delicatulum.*

*AA.* Striations running in two directions.

*b.* Transverse and longitudinal striations equally distant. 2. *G. acuminatum.*

*bb.* Transverse striations more distant than longitudinal.

*c.* Lanceolate.

*d.* Ends acute. 3. *G. kützingii.*

*dd.* Ends acuminate. 4. *G. parkerii.*

*cc.* Linear.

*d.* Tapering toward the ends. 5. *G. spencerii.*

*dd.* Ends abruptly and obliquely rounded. 6. *G. scalproides.*

*bbb.* Longitudinal striations more distant than transverse. 7. *G. attenuatum.*

**Gyrosigma delicatulum** (W. Sm.) Elmore.

*Pleurosigma delicatulum* W. Sm. *Ann. Hist., 2d series, vol. 9, p. 6, pl. 1, fig. 5. 1852.*

Pl. 13, figs. 512–513.

Narrow, lanceolate, 139–280 $\mu$ long, 14–30 $\mu$ wide, apices slightly acute or rounded; raphe nearly central, slightly excentric near the ends; striations crossing in three directions, 18–25 in 10 $\mu$.

In creeks and rivers: Crete, Julian, Lincoln, North Platte

2. **Gyrosigma acuminatum** (Kütz.) Cl. *Syn. Nav. Diat., I, p. 114. 1894.*

*Frustulia acuminata* Kütz. in *Linnaea, VIII, p. 555. 1833. Syn. Diat., p. 27, fig. 36. 1834.*

Pl. 13, figs. 514–515.

Lanceolate, 100–180 $\mu$ long, 10–20 $\mu$ wide, tapering toward the rounded ends; raphe central; striations running in two directions, longitudinal and transverse equally distant, 18–20 in 10 $\mu$.

In creeks, rivers, etc.: Ashland, Crete, Julian, Lincoln.
Devils Lake, N. Dak.

3. **Gyrosigma kützingii** (Grun.) Cl. in *Cl. & Grun. Arct. Diat., I, p. 115. 1894.*

*Pleurosigma kützingii* Grun. *Verh., p. 561, pl. 4, fig. 3. 1860.*

Pl. 13, fig. 516.

Lanceolate, sigmoid, with acute ends, 80–120 $\mu$ long, 12–15 $\mu$ wide; raphe sigmoid, median; central nodule somewhat elongated; longitudinal striations closer than the transverse; transverse 20–23 in 10 $\mu$, longitudinal 25–26 in 10 $\mu$.

In creeks, rivers, springs, etc.: Central City, Culbertson, Fairbury, Julian, Lincoln, Louisville, Ruby, Stromsburg, Tekamah, Wahoo, Weeping Water.

Devils Lake, N. Dak.; Little White River, Rapid City, Rosebud, S. Dak.; Stockton, Cal.; Muskingum River, New Concord, Ohio.

4. **Gyrosigma parkerii** Harrison in *Q. J. M. S., p. 104. 1860.*

Pl. 13, fig. 517.

Lanceolate, sigmoid, with long acuminate ends, 80–150 $\mu$ long, 14–25 $\mu$ wide; raphe median except at the ends, where it is ex-

centric; transverse striations 20–23 in 10 μ, longitudinal 24–27 in 10 μ.

In San Joaquin River, Stockton, Cal.

5. **Gyrosigma spencerii** (W. Sm.) Cl. *Syn. Nav. Diat., I, p. 117. 1894.*

*Pleurosigma spencerii* W. Sm. in *Ann. Nat. Hist., p. 12, pl. 2, fig. 15. 1852.*

Pl. 13, figs. 518–519.

Linear-lanceolate, 58–220 μ long, 10–25 μ wide, tapering toward the rounded ends; transverse striations more distant than the longitudinal; transverse 17–22 in 10 μ, longitudinal 22–24 in 10 μ; raphe sigmoid, median.

In creeks, rivers, ponds, etc.: Brock, Crete, Grand Island, Johnson, Lincoln, Norfolk, Peru, Pleasant Dale, Rulo, St. Michael, Salem, Stromsburg, Talmage, Wahoo, Weeping Water, West Point.

Stockton, Cal.; Emporia, Kansas.

6. **Gyrosigma scalproides** (Rabenh.) Cl. *Syn. Nav. Diat., I, p. 118. 1894.*

*Pleurosigma scalproides* Rabenh. *Alg. Eu., No. 1101. 1861.*

Pl. 13, fig. 520.

Linear, slightly sigmoid, 57–58 μ long, 9–10 μ wide, apices obliquely rounded; raphe median, nearly straight; central nodule elongated; transverse striations more distant than the longitudinal, transverse about 22 and longitudinal about 29 in 10 μ.

In creeks with *Spirogyra, Oscillatoria,* etc.: Alma, Cook, Grand Island, Lincoln, Norfolk, Orleans, Stanton, Talmage, Weeping Water, West Point.

Stockton, Cal.

7. **Gyrosigma attenuatum** (Kütz.) Cl. *Syn. Nav. Diat., I, p. 115. 1894.*

*Frustulia attenuata* Kütz. *Dec., No. 83* (according to Lagerst.).

Pl. 23, fig. 857.

Sigmoid, tapering from the middle to the obtuse ends, 180–260 μ long, 25–28 μ wide; raphe central; longitudinal striations 10–12 in 10 μ, transverse striations 14–16 in 10 μ.

Dunning, Norfolk.

Fossil in Pleistocene stratum, Valentine.

### 27. Amphiprora

*Amphiprora* Ehr. *Amer., p. 113. 1843; Amphicampa* Rabenh.; *Amphitropis* Pfitz.; *Entomoneis* Ehr.

Etym., from Gr. ἀμφί, both, and πρώρα, the prow of a boat, so called on account of the two-winged margin of the cells.

Cells single, free, twisted, lanceolate in valve view, hour-glass shape in girdle view with a sigmoid girdle; interzones present; valves convex with a raphe concealed in a sigmoid, emarginate keel; central and terminal nodules present; valves transversely striate, rarely scattered-punctate. Chromatophore a single large plate lying next to the girdle.

*A.* Keel undulate. 1. *A. ornata.*
*AA.* Keel not undulate. 2. *A. alata.*

1. **Amphiprora ornata** Bailey. *Micro. Obs. in S. C., p. 38, pl. 2, figs. 15, 23. 1850.*

Pl. 14, fig. 521.

Valves membranous, thin, deeply constricted in the middle in girdle view, twisted around the longitudinal axis, 45–80 μ long, 34–50 μ wide; keel undulate; striations radiate, finely granular, 20–22 in 10 μ; connecting zone with 8–10 well-marked plaits.

In Schimmer's Lake, Grand Island.
Stockton, Cal.

2. **Amphiprora alata** (Ehr.) Kütz. *Bacill., p. 107, pl. 3, fig. 63. 1844.*

*Navicula alata* Ehr. *Ber., p. 18. 1840.*

Pl. 14, figs. 522–525.

Linear-elliptic with apiculate apices, 50–130 μ long, 20–47 μ wide; keel sigmoid, not undulate, furnished with elongated dots, about 4 in 10 μ; striations fine, granular, 11–16 in 10 μ; cells usually twisted around the longitudinal axis, hour-glass shape in girdle view. Fig. 524 shows process of dividing.

In Salt Creek, Lincoln; Little Salt at Arbor; with *Oscillatoria* at Omaha; and at Ashland and Fairbury.

### 28. Gomphonema.

*Gomphonema* Ag. *Syst. Alg., p. 15. 1824. Crystallia* Sommerfels; *Dendrella* Bory; *Diomphala* Ehr.; *Gomphoneis*

Cleve; *Gomphonella* Rabenh.; *Sphenella* Kütz.; *Sphenosira* Ehr.

Etym., from Gr. γόμφος, wedge, and νήμα, thread, the plant having the appearance of a wedge borne on the end of a thread.

Cells single, mostly stalked, or in gelatinous masses, cuneate in both girdle and valve views; interzones present; valves bilaterally symmetrical, often with one or two constrictions; raphe straight with central and terminal nodules; surface transversely punctate-striate, the striations sometimes lacking opposite the central nodule, giving the appearance of a stauros. Chromatophore one large plate lying next to the girdle. Auxospores two from two mother cells in a common gelatinous envelope.

*A.* With an isolated dot on one side of the central nodule.
  *b.* Median striations alternately long and short. 1. *G. constrictum.*
  *bb.* Median striations not alternately long and short.
    *c.* Without stauroneiform area.
      *d.* Not lanceolate-rostrate.
        *e.* Upper apex apiculate.
          *f.* Gibbous in the middle. 2. *G. acuminatum.*
          *ff.* Not gibbous in the middle. 3. *G. augur.*
        *ee.* Upper apex not apiculate.
          *f.* Upper apex broadly rounded.
            *g.* With rows of dots between the striations. 4. *G. herculeanum.*
            *gg.* No dots between the striations. 5. *G. eriense.*
          *ff.* Upper apex not broadly rounded.
            *g.* Striations coarsely punctate. 6. *G. lanceolatum.*
            *gg.* Striations not coarsely punctate.
              *h.* Striations 7 or more in 10 μ; ventral area narrow. 7. *G. montanum.*
              *hh.* Striations fewer than 7 in 10 μ; ventral area broad. 8. *G. validum.*
      *dd.* Lanceolate-rostrate.
        *e.* Middle area round. 9. *G. parvulum.*
        *ee.* Middle area on one side of the central nodule. 10. *G. angustatum.*
    *cc.* With stauroneiform area.
      *d.* At least one end of the valve acute. 11. *G. gracile.*
      *dd.* Both ends nearly equally obtuse. 12. *G. intricatum.*

*AA.* No isolated dot.
*b.* Hyaline area distinct. 13. *G. olivaceum.*
*bb.* Hyaline area narrow. 14. *G. exiguum.*

1. **Gomphonema constrictum** Ehr. *Abh. Ber. Acad., p. 63. 1830.* (According to Kütz., *Bacill., p. 86.*)

Pl. 14, figs. 526–529.

Cuneate, 37–60 $\mu$ long, 7–11 $\mu$ wide, inflated in the middle and deeply constricted between the middle and the upper end, which is broadly rounded; striations granular, 10–12 in 10 $\mu$, radiate, alternately long and short around the central nodule; an isolated dot on one side of the central nodule.

In creeks, rivers, etc., also fossil: Andrews, Atkinson, Broken Bow, Burge, Cedar Creek, Central City, Clear Lake, Cody Lake, Crawford, Dewey Lake, Dismal River, Druly Lake, Dunning, Ewing, Fremont, Grand Island, Halsey, Johnson, Lodi, Long Pine, New Helena, Newport, North Platte, Oakdale, Pelican Lake, Rupert, Scottsbluff, Talmage, Tekamah, Thedford, St. Michael, St. Paul, Seneca, Seward, South Bend, Stanton, Thedford, Valentine, Wann, Weeping Water, Willow Lake, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Loup City, Merriman, Mullen, Spalding, Thedford, Valentine, Wheeler County.

Cutmeat, Rapid City, Rosebud, S. Dak.; Cheyenne, Wyo.; Stockton, Cal.; Ft. Collins, Colo.; Blackhand, Ohio.

2. **Gomphonema acuminatum** Ehr. *Inf., p. 217, No. 308, pl. 18, fig. 4. 1838.*

Pl. 14, figs. 530–534; pl. 23, figs. 845, 847.

Cuneate, 19–70 $\mu$ long, 6–12 $\mu$ wide, inflated in the middle, constricted below the upper end, which is more or less triangular, apiculate; striations 9–12 in 10 $\mu$, radiate, granular, shortened on one side of the central nodule, leaving a hyaline space in which is an isolated dot. *G. turris* Ehr. is made a variety of *G. acuminatum* by Cleve, *Syn. Nav. Diat., I, 184.*

In springs, creeks, lakes, rivers, etc., with *Spirogyra* and other algae, also fossil: Atkinson, Bellevue, Broken Bow, Central City, Clear Lake, Cody Lake, Dismal River, Dunning, Fremont, Grand Island, Hackberry Lake, Halsey, Hyannis, Lakeside, Long Pine, New Helena, North Platte, Ruby, Scottsbluff, Snake River, Talmage, Tekamah, Thedford, Valentine, Whitman, Woodlake.

Fossil: Agate, Greeley County, Mullen, Thedford, Valentine.

Blackpipe, Cutmeat, Little White River, Rapid City, Turtle River, S. Dak.; Chippewa Falls, Wis.

3. **Gomphonema augur** Ehr. *Abh., p. 17. 1840.*
Pl. 14, fig. 535; pl. 23, fig. 849.

Cordate-cuneate, 30–50 μ long, 9–12 μ wide, upper end obtuse-apiculate, lower end attenuate, slightly rostrate; striations about 10 in 10 μ, granular, radiate, shortened on one side of the central nodule, leaving a clear space in which is an isolated dot.

In rivers, creeks, etc., also fossil: Anselmo, Crawford, Dismal River, Dunning, Gordon Creek, Grand Island, Halsey, Hyannis, Oakdale, Seneca, Stromsburg, Thedford, Trenton, Valentine.
Fossil: Cherry County, Loup City, Spalding, Thedford.
Rosebud, S. Dak.

4. **Gomphonema herculeanum** Ehr. *Ber., p. 78. 1845.*
Pl. 14, fig. 536.

Cuneate at both ends, 38–100 μ long, 12–22 μ wide, upper end broadly rounded, lower end acute, sometimes attenuate; striations granular, alternating with a double row of granules, radiate, 9–10 in 10 μ, shortened in the middle, leaving a rounded hyaline space around the central nodule containing an isolated dot.

Snake River.
Fossil: Mullen.

5. **Gomphonema eriense** Grun. *Alg. Kasp. Meer., p. 109. 1878.*
Pl. 14, figs. 537–538; pl. 23, fig. 848.

Broadly lanceolate, 32–42 μ long, 12–14 μ wide; apex rounded; striations radiate, shortened, leaving a rounded hyaline space around the central nodule with very distinct isolated dot. The specimens from Lake Erie are up to 90 μ long.

With *Lyngbya* in Long Pine Creek, Long Pine; New Helena, St. Paul. Little White River, S. Dak.; pond on island in Lake Erie, Put-in Bay, Ohio.

6. **Gomphonema lanceolatum** Ehr. *Amer., pl. 2, I, 37. 1843.*
*Gomphonema lanceolatum* Kütz. *Bacill., p. 87, pl. 29, fig. 73. 1844.*
Pl. 14, fig. 539.

Lanceolate, clavate, 27–70 μ long, 10–12 μ wide, gradually tapering from the middle to the obtuse apex and base; striations granular, slightly radiate, 10–13 in 10 μ, shortened at the center, leaving

a rounded hyaline space with an isolated dot. The form called var. *insignis* is the only one yet found in Nebraska.

With *Vaucheria*, Crete.

7. **Gomphonema montanum** Schum. *Diat. Tatra, p. 67, pl. 3, fig. 35b. 1867.*

*Gomphonema subclavatum* Grun. *Diat. Fr. Jos. Land, p. 46, pl. 1, fig. 13. 1884.*

Pl. 14, figs. 540–553.

Clavate, 10–90 $\mu$ long, 5–13 $\mu$ wide, sometimes more or less triundulate, apices rounded; striations 7–14 in 10 $\mu$, slightly radiate, 2 or 3 of those on one or both sides of the central nodule shortened, leaving a hyaline space in which is an isolated dot. Very variable in form and size. The varieties *subclavatum* and *commutatum* are probably only forms.

Very common in water everywhere, also fossil: Alma, Andrews, Anselmo, Ashland, Atkinson, Benkleman, Bratton, Brock, Broken Bow, Brownlee, Burge, Callaway, Cedar Creek, Central City, Chadron, Clear Lake, Cody Lake, Columbus, Crawford, Crete, Culbertson, Dewey Lake, Dismal River, Dunning, Emerald, Emmett, Fremont, Grand Island, Hackberry Lake, Halsey, Hemingford, Holbrook, Hyannis, Lakeside, Lincoln, Lodi, Long Lake, Long Pine, Louisville, Mason City, Meadow, Melia, Milford, New Helena, Newport, Norfolk, North Platte, Northport, O'Neill, Orella, Orleans, Pelican Lake, Phalaris Lake, Pleasant Lake, Red Cloud, Ruby, Rupert, St. Michael, St. Paul, Scottsbluff, Seneca, Seward, South Bend, Stanton, Stromsburg, Talmage, Tekamah, Thedford, Tioga, Trenton, Valentine, Wahoo, Wann, Watts Lake, Weeping Water, West Point, Whitman, Willow Lake, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Loup City, Merriman, Mullen, Spalding, Thedford, Valentine, Williams's Canyon.

Belvidere, Blackpipe, Conata, Corn Creek, Cutmeat, Kadoka, Little White River, Norris, Redleaf, Rosebud, S. Dak.; Cheyenne, Wyo.; Devils Lake and fresh water near Devils Lake, N. Dak.; Chippewa Falls, Wis.; Fresno, Cal.; Granville, Ohio; Emporia, Kansas.

8. **Gomphonema validum** Cl. *Syn. Nav. Diat., I, p. 185. 1895.*

Pl. 15, figs. 554–556.

Clavate, regular, or slightly biconstricted; apices rostrate-apiculate, cuneate, or rounded; 65–95 $\mu$ long, 7–13 $\mu$ wide; striations slightly radiating, 5–7 in 10 $\mu$, shortened, leaving a moderately wide longitudinal hyaline area not dilated in the middle; isolated dot often indistinct.

Pools, rivers, etc.: Grand Island, Hyannis, Norfolk, Thedford.
Fossil: Hay Springs, Loup City, Merriman, Spalding.
Sully's Hill, N. Dak.

9. **Gomphonema parvulum** (Kütz.) Rabenh. *Fl. Eu. Alg., I, p. 291. 1864.*

*Sphenella parvula* Kütz. *Bacill., p. 83, pl. 30, fig. 63. 1844.*

Pl. 15, figs. 557–561.

Lanceolate-clavate, 19–30 μ long, 6–17 μ wide, apex rounded, rostrate, or capitate; gradually tapering from the middle to the base, which is sometimes slightly capitate; striations 12–14 in 10 μ, nearly transverse, shortened on one side opposite the central nodule, leaving a hyaline space in which is an isolated dot, often indistinct. In the form called var. *micropus,* fig. 561, the striations are more distant, about 8 in 10 μ. Var. *lanceolatum,* fig. 557, is a more lanceolate form.

Common attached to filamentous algae, sticks, stones, etc., also fossil: Ainsworth, Auburn, Broken Bow, Brownlee, Cedar Creek, Cody Lake, Crawford, Dismal River, Dunning, Ewing, Fairbury, Fremont, Glen Rock, Gordon Creek, Grand Island, Hackberry Lake, Hemingford, Holt County, Ithaca, Lincoln, Long Lake, Long Pine, Louisville, Mason City, Minden, New Helena, North Platte, Oakdale, Orella, Orleans, Peru, Pleasant Dale, Polk, Red Cloud, Ruby, St. Michael, Scottsbluff, Seneca, Stanton, Stromsburg, Talmage, Thedford, Valentine, Wahoo, Weeping Water, Whitman, Willow Lake.

Fossil: Agate, Cherry County, Greeley County, Loup City, Mullen, Thedford, Williams's Canyon.

Belvidere, Cutmeat, Kadoka, Rapid City, Rosebud, S. Dak.; Devils Lake, N. Dak.; Cheyenne, Wyo.; Fresno, Cal.; Blackhand, Ohio.

10. **Gomphonema angustatum** (Kütz.) V. H. *Syn., p. 126, pl. 24, figs. 48, 49, 50. 1885.*

*Sphenella angustata* Kütz. *Bacill., p. 83, pl. 8, fig. 4. 1844.*

Pl. 15, fig. 562.

Cuneate, 30–44 μ long, 7–8 μ wide, nearly symmetrical to the transverse axis, but the upper end somewhat larger, both ends more or less capitate; striations delicate, 8–12 in 10 μ, radiate, shortened on one side of the central nodule; isolated dot indistinct.

In creek, Andrews.

11. **Gomphonema gracile** Ehr. *Inf., p. 217, pl. 18, fig. 3. 1838.*
Pl. 15, figs. 563–566.

Lanceolate or rhomboidal, 25–92 μ long, 7–13 μ wide, apices nearly alike; striations 7–15 in 10 μ, nearly transverse, those in the middle shortened or slightly more distant, leaving a transverse space in which is an isolated dot, often indistinct.

In creeks, rivers, tanks, ponds, lakes, etc., also fossil: Broken Bow, Clear Lake, Cody Lake, Dewey Lake, Dismal River, Dunning, Emerald, Emmett, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Hyannis, Lakeside, Lodi, Mason City, New Helena, Newport, Orella, Orleans, Pleasant Dale, Rupert, Scottsbluff, Seneca, Stromsburg, Thedford, Valentine, Watts Lake, Willow Lake, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Loup City, Mullen. Little White River, Norris. Turtle River, S. Dak.; Stockton, Cal.

12. **Gomphonema intricatum** Kütz. *Bacill., p. 87, pl. 9, fig. 4. 1844.*
Pl. 15, figs. 567–570; pl. 23, fig. 846.

Slender, linear-lanceolate, 21–87 μ long, 4–11 μ wide, more or less swollen in the middle, apices rounded; striations 9–12 in 10 μ, nearly transverse, shortened opposite the central nodule, leaving a rounded space in which is an isolated dot. Very variable in form and size, central area sometimes almost lacking as in fig. 568.

In creeks, ponds, etc., also fossil: Brock, Crawford, Emerald, Grand Island, Red Cloud, Stromsburg, Talmage, Wann, Woodlake.

Fossil: Greeley County.

13. **Gomphonema olivaceum** (Lyngb.) Kütz. *Bacill., p. 85, pl. 7, figs. 13, 15. 1844.*
*Echinella olivacea* Lyngb. *Tent. Hydr. Dan., p. 209, pl. 70, fig. c, 1–3. 1819.*
Pl. 15, figs. 571–574.

Clavate, rarely sublanceolate, 15–34 μ long, 5–8 μ wide, apex broad and rounded, base narrower; striations 10–14 in 10 μ, usually shortened or lacking in the center, forming a pseudostauros, curved or radiate in the middle, the rest nearly transverse.

Very abundant in creeks, especially in the spring forming brown, gelatinous masses coating stones, sticks, and the bottom of the stream: Antioch, Ashland, Blue Springs, Cairo, Grand Island, Haigler, Lincoln, O'Neill, Seneca, Valentine, Wahoo, Woodlawn.

Corn Creek, S. Dak.; fresh water near Devils Lake, N. Dak.; New Concord, Ohio; Emporia, Kansas.

14. **Gomphonema exiguum** Kütz. *Bacill., p. 84, pl. 30, fig. 58. 1844.*

Pl. 15, figs. 575–576.

Clavate or cuneate, 10–25 μ long, 2–3 μ wide, apex rounded, obtusely angular, or slightly rostrate, base more acute; striations nearly transverse, 15–18 in 10 μ, extending nearly to the raphe and leaving a very narrow hyaline space which is slightly wider opposite the central nodule.

This is a marine species, but Schönfeldt, *Bacill., p. 125,* reports it in fresh water.

In shell marl, Loup City.

## 29. Rhoicosphenia

*Rhoicosphenia* Grun. in *Wien. Verh., X, p. 511. 1860.*

Etym., from Gr. ῥοικός, curved, and σφήν, wedge, an appropriate name, the cells being wedge-shape like *Gomphonema*, but curved.

Cells mostly stalked, cuneate in both girdle and valve view, curved in girdle view; interzones present, valves straight, bilaterally symmetrical, transversely striate, unlike, the concave valve with raphe and central and terminal nodules, the convex valve without nodules and with a pseudoraphe. Chromatophores and auxospores as in *Gomphonema.*

**Rhoicosphenia curvata** (Kütz.) Grun. *Alg. Nov., p. 8. 1867.*
*Gomphonema curvatum* Kütz. *Linnaea, X, p. 567, pl. 16, fig. 51. 1833. Syn., p. 39, fig. 51. 1834.*

Pl. 15, figs. 577–581.

Cuneate or spatulate, 15–27 μ long, 3–8 μ wide, upper end rounded or slightly capitate, lower end more acute, but often capitate; upper valve with nearly parallel but slightly radiate striations, 9–10 in 10 μ, reaching to the pseudoraphe, no raphe or nodules; lower valve with striations slightly radiate, 10–14 in 10 μ, extending nearly to the raphe, but slightly shortened opposite the central nodule.

In springs, creeks, rivers, etc., with *Ulothrix, Cladophora,* or other

algae, also fossil: Andrews, Arago, Ashland, Brock, Cedar Creek, Central City, Crawford, Dunning, Grand Island, Haigler, Minden, North Platte, Red Cloud, Ruby, Scottsbluff, Snake River, South Bend, Trenton, Valentine, Wann, Whitman.

Fossil: Thedford.

Belvidere, Blackpipe, Cutmeat, Little White River, Norris, Rapid City, Redleaf, Rosebud, Turtle River, S. Dak.; Devils Lake, N. Dak.; Cheyenne, Wyo.; Ft. Collins, Colo.

## 30. Cymbella

*Cymbella* Ag. *Consp., p. 1. 1830. Cymbophora* Breb.; *Gloeodictyon* Ag.; *Gloeonema* Ehr.; *Lunularia* Bory; *Syncyclia* Ehr.

Etym., diminutive of Lat. *cymba,* boat, the same meaning as *Navicula;* but *Cymbella* is the shape of a boat viewed from the side and *Navicula* is the shape of a boat viewed from above.

Cells single, stalked (often becoming free), or enclosed in gelatinous tubes, oblong and straight in girdle view; no interzones; valves lunate, not symmetrical; raphe somewhat excentric, arcuate, rarely straight; central and terminal nodules present; surface transversely striate, without ribs. Chromatophore one large plate the middle of which lies next to the longer girdle side of the cell, the sides reflexed and lying next to both valves and reaching almost to the girdle on the shorter side. In auxospore formation two cells lying parallel with one another surround themselves with a thick gelatinous coating and throw off the valves; the contents of each divides into two, forming four cells, these four cells unite into two, each uniting with a cell from the other mother cell, forming two auxospores.

*A.* Ventral and dorsal margins bent in opposite directions.
  *b.* Broadly lanceolate or sub-elliptic.
    *c.* Apices slightly produced or capitate, axial area wide, large forms. 1. *C. ehrenbergii.*
    *cc.* Apices rostrate-cuspidate, axial area narrower. 2. *C. cuspidata.*
    *ccc.* Apices capitate, small forms. 3. *C. amphicephala.*
  *bb.* More narrowly lanceolate, dorsal margin much more curved than the ventral.
    *c.* Apices slightly attenuate. 4. *C. pusilla.*
    *cc.* Apices slightly rostrate or rostrate-capitate.
      *d.* Ventral margin gibbous. 5. *C. leptoceras.*

*dd.* Ventral margin not gibbous.
*e.* Raphe arcuate, striations distant. 6. *C. affinis.*
*ee.* Raphe nearly straight, striations not so distant. 7. *C. naviculiformis.*
*bbb.* Naviculoid, ventral margin nearly as convex as the dorsal. 8. *C. aequalis.*
*AA.* Ventral and dorsal margins bent in the same direction.
*b.* Terminal nodules not elongated.
*c.* Striations not interrupted by a broad hyaline space on the ventral side of the valve.
*d.* Raphe regularly curved toward the dorsal margin.
*e.* Striations of very coarse dots. 9. *C. gastroides.*
*ee.* Striations of finer dots.
*f.* Large forms. 10. *C. lanceolata.*
*ff.* Small forms. 11. *C. parva.*
*dd.* Ends of the raphe in the middle of the valve bent toward the ventral side. 12. *C. cymbiformis.*
*cc.* Striations interrupted by a hyaline space on the ventral side of the central nodule leaving the ends of the striations as isolated dots. 13. *C. cistula.*
*bb.* Terminal nodules elongated. 14. *C. helvetica.*

1. **Cymbella ehrenbergii** Kütz. *Bacill., p. 79, pl. 6, fig. 11. 1844.* *Navicula inaequalis* Ehr. *Inf., pl. 13, fig. 18. 1838.*
Pl. 15, figs. 582, 583, 586, 587.

Elliptic-lanceolate, 90–142 μ long, 28–38 μ wide, apices attenuate or rostrate; ventral margin nearly as convex as the dorsal; raphe nearly straight; striations 5–9 in 10 μ on the dorsal side in the middle, closer elsewhere, slightly shortened, leaving a narrow space along the raphe, more shortened opposite the central nodule, leaving a rounded space. Differs from *C. cuspidata* mainly in size and in the wider space along the raphe.

In creeks and rivers with *Cladophora* and other algae, also fossil: Brownlee, Dismal River, Dunning, Holt County, Seneca, Snake River, St. Michael, Talmage, Thedford, Weeping Water.

Fossil: Cherry County, Greeley County, Hay Springs, Loup City, Mullen, Thedford.

2. **Cymbella cuspidata** Kütz. *Bacill., p. 79, pl. 3, fig. 40. 1844.*
Pl. 15, figs. 584, 585, 588.

Broadly linear-lanceolate, ventral side almost as convex as the

dorsal, 40–95 $\mu$ long, 14–24 $\mu$ wide, rostrate or rostrate-capitate; raphe nearly straight; striations radiate, 6–10 in 10 $\mu$ on the dorsal side in the middle, elsewhere closer, extending nearly to the raphe except opposite the central nodule, where they are shortened, leaving a rounded hyaline space.

Fig. 588 seems to be an abnormal form of *C. cuspidata.*

In creeks, rivers, lakes, etc., also fossil: Bellevue, Dewey Lake, Dismal River, Grand Island, Hackberry Lake, Halsey, New Helena, Pelican Lake, Seneca, Snake River, Wahoo.

Fossil: Agate, Cherry County, Greeley County, Loup City, Mullen, Spalding, Thedford, Valentine, Wheeler County.

Blackpipe, Little White River, Rosebud, S. Dak.; Cheyenne, Wyo.

3. **Cymbella amphicephala** Naeg. in *Kütz. Spec., p. 890. 1849.*

Pl. 16, fig. 589.

Elliptic, 25–40 $\mu$ long, 9–10 $\mu$ wide, ventral margin convex or nearly straight, ends rostrate or rostrate-capitate; raphe nearly straight, nearer the ventral margin; striations radiate, 10–14 in 10 $\mu$ on the dorsal side in the middle, closer elsewhere, finely granular, extending nearly to the raphe, leaving a very narrow space which is slightly wider opposite the central nodule.

In creeks and lakes: Andrews, Clear Lake, Long Pine, Snake River.

In creek at Cheyenne, Wyo.; Rapid City, S. Dak.; Blackhand, New Concord, Put-in Bay, Rodney, Ohio.

4. **Cymbella pusilla** Grun. in *A. Schm. Atlas, pl. 9, figs. 36, 37. 1875.*

Pl. 16, fig. 590.

Lanceolate, 23–40 $\mu$ long, 5–9 $\mu$ wide, apices acute, often slightly rostrate; raphe straight; striations radiate, 11–18 in 10 $\mu$ in the middle on the dorsal side, closer elsewhere, extending nearly to the raphe throughout.

In Pelican Lake.

Devils Lake, N. Dak.; Stockton, Cal.

5. **Cymbella leptoceras** (Ehr.) Rabenh. *Süssw. Diat., pl. 7, fig. 14. 1853. Fl. Eu. Alg., p. 81. 1864.*

*Cocconema leptoceras* Ehr. *Amer., pl. 1, II, fig. 30. 1843.*

Pl. 16, figs. 591–592.

Dorsal margin evenly curved, ventral nearly straight or slightly

convex, more or less gibbous, 20–56 μ long, 8–12 μ wide; ends obtuse, slightly attenuate; raphe curved toward the dorsal margin; striations nearly perpendicular to the margins, finely granular, 8–11 in 10 μ in the middle on the dorsal side, closer elsewhere, extending nearly to the raphe, leaving a narrow space which is not wider opposite the central nodule, or only slightly so. Van Heurck's figure of *C. leptoceras* var. *elongata, Diat., pl. 1, fig. 33,* closely resembles the form found here.

On muddy banks: Benkleman, Mason City.
Rapid City, S. Dak.

6. **Cymbella affinis** Kütz. *Bacill., p. 80, pl. 6, fig. 15. 1844.*
Pl. 16, fig. 593.

Semi-elliptical or semi-lanceolate, 25–40 μ long, 7–13 μ wide; dorsal margin convex, ventral margin nearly straight, slightly gibbous, ends rounded, sometimes more or less capitate; raphe curved toward the dorsal margin; striations extending nearly to the raphe, not shortened opposite the central nodule except the central one on the ventral side, which is shorter, and in the space which is left by it there is a single dot; striations 9–11 in 10 μ on the dorsal side in the middle, closer elsewhere, finely granular, radiate.

In creeks: Crawford, Meadow.

7. **Cymbella naviculiformis** Auersw. in *Kirch. Alg. Schles., p. 187. 1878.*
Pl. 16, figs. 594–598.

Elliptic-lanceolate, 30–48 μ long, 9–16 μ wide, apices attenuate-rostrate or capitate; raphe nearly straight; striations radiate, 10–14 in 10 μ in the middle on the dorsal side, closer elsewhere, shortened, leaving a narrow space along the raphe, those opposite the central nodule more shortened, leaving a rounded space.

In lakes, creeks, etc.: Andrews, Clear Lake, Dunning, Hackberry Lake, Pelican Lake, Thedford, Whitman.
Weta, S. Dak.

8. **Cymbella aequalis** W. Sm. *Brit. Diat., II, p. 84. 1856.*
*Cymbella obtusa* Greg. in *Mic. Journ., IV, p. 5, pl. 1, fig. 9. 1855.*
Pl. 16, figs. 599–600.

Elliptic, 30–52 μ long, 11–14 μ wide, dorsal margin more convex than the ventral; ends obtuse, sometimes slightly attenuate; raphe straight or only slightly curved toward the dorsal margin; striations finely granular, 10–14 in 10 μ in the middle on the dorsal side, closer elsewhere, nearly perpendicular to the margins, extending nearly to the raphe, but leaving a distinct space which is slightly wider opposite the central nodule.

In creeks at Andrews and in Clear Lake.

9. **Cymbella gastroides** Kütz. *Bacill., p. 79, pl. 6, fig. 4b. 1844.*
*Frustulia gastroides* Kütz. *Diat., p. 15, fig. 9. 1834.*
*Cocconema asperum* Ehr. *Ber. Berl. Akad., p. 12, I, fig. 1. 1840.*
*Cymbella aspera* (Ehr.) Cl. *Syn. Nav. Diat., I, p. 175. 1894.*
Pl. 16, figs. 601–606.

Broadly lunate, 54–180 μ long, one specimen 244 μ long, 19–37 μ wide, ventral margin slightly concave, usually gibbous; ends obtuse; raphe arcuate with ends bent toward the dorsal margin; striations perpendicular to the margins, 5–9 in 10 μ on the dorsal side in the middle, closer elsewhere, composed of coarse dots, slightly shortened, leaving a distinct space along the raphe which is wider opposite the central nodule. Varies from nearly semicircular to long lunate. Differs from *C. lanceolata* in its usually broader form, striations of coarser dots, and wider space along the raphe. Fig. 606 is of a fossil form found at Thedford.

Common in creeks, rivers, springs, tanks, etc., with *Cladophora, Spirogyra,* or other filamentous algae, also fossil: Andrews, Anselmo, Bellevue, Benkleman, Burge, Callaway, Central City, Crawford, Culbertson, Dismal River, Dunning, Gordon Creek, Grand Island, Hackberry Lake, Haigler, Halsey, Holt County, Lodi, Long Pine, Louisville, Meadow, New Helena, Newport, North Platte, Northport, Oakdale, Orelans, Red Cloud, Ruby, St. Paul, Seneca, Snake River, South Bend, Tekamah, Thedford, Trenton, Valentine, Wann.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Mullen, Spalding, Thedford, Valentine, Williams's Canyon.

Blackpipe, Cutmeat, Little White River, Norris, Rapid City, Rosebud, S. Dak.; Cheyenne, Wyo.; Ft. Collins, Colo.; Stockton, Cal.

10. **Cymbella lanceolata** (Ehr.) Kirchn. *Alg. Schles., p. 188. 1878.*
*Cocconema lanceolatum* Ehr. *Inf., p. 224, pl. 19, fig. 6. 1838.*

Pl. 16, figs. 607–610; pl. 23, fig. 856.

Lunate, 80–218 $\mu$ long, 16–32 $\mu$ wide, ventral margin slightly concave, usually gibbous in the middle, apices obtuse; raphe arcuate with ends bent toward the dorsal side; striations nearly perpendicular to the margins, 6–10 in 10 $\mu$ on the dorsal side in the middle, closer elsewhere, composed of fine dots extending nearly to the raphe, leaving a very narrow space which is slightly wider opposite the central nodule.

In creeks, rivers, ponds, etc., also fossil: Andrews, Broken Bow, Cedar Creek, Chadron, Crawford, Dewey Lake, Dismal River, Grand Island, Hackberry Lake, Halsey, Norfolk, North Platte, Oakdale, St. Michael, Scottsbluff, Seneca, Stanton, Thedford, Valentine, Wann, West Point, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Loup City, Mullen, Thedford, Valentine, Williams's Canyon.

Stockton, Cal.; Ft. Collins, Colo.; Blackhand, Put-in Bay, Ohio.

11. **Cymbella parva** W. Sm. 1852 according to *Cleve Syn. Nav. Diat., I, p. 172.*

*Cocconema parvum* W. Sm. *Brit. Diat., I, p. 76, pl. 23, fig. 222, and pl. 24, fig. 222. 1853.*

Pl. 16, figs. 611–612.

Lunate, 30–57 $\mu$ long, 9–12 $\mu$ wide, ventral margin slightly concave, usually gibbous in the middle, apices obtuse; raphe arcuate with ends bent toward the dorsal side; striations nearly perpendicular to the margins, 8–10 in 10 $\mu$ on the dorsal side and 12–13 on the ventral side in the middle, closer toward the ends, extending nearly to the raphe, leaving a very narrow hyaline space which is very slightly larger opposite the central nodule.

Grand Island, Lakeside, New Helena, North Platte, St. Paul, Thedford, Valentine.

Fossil: Hay Springs, Valentine.

Devils Lake and fresh water near Devils Lake, N. Dak.; Cutmeat, Rapid City, S. Dak.

12. **Cymbella cymbiformis** Ag. *Consp., p. 10, 1832.* (According to *Kütz. Syn. Diat., p. 11.*)

Pl. 16, figs. 613–615.

Lunate with nearly straight, sometimes slightly gibbous ventral

margin, 38–100 $\mu$ long, 10–14 $\mu$ wide; ends obtuse or truncate; raphe slightly curved toward the dorsal margin, its ends bent toward the dorsal side, the ends at the central nodule bent toward the ventral side; striations slightly radiate, finely granular, 7–10 in 10 $\mu$ in the middle on the dorsal side, closer elsewhere, extending nearly to the raphe, scarcely shortened opposite the central nodule, the central one or two on the ventral side interrupted, leaving a dot at the end. Fig. 615 is from a specimen in *Rabenh. Alg. Eu., 1168.* The interrupting of the middle striations is not at all constant in Rabenhorst's specimens.

In creeks, etc., also fossil: Grand Island, Mason City.
Fossil: Mullen, Wheeler County.
Cheyenne, Wyo.

13. **Cymbella cistula** (Hempr.) Kirchn. *Alg. Schles., p. 189. 1878.*

*Bacillaria cistula* Hempr. *Ehr. Symb. Phys. Phyto., pls. II, IV, fig. 10. 1828.*

Pl. 16, figs. 616–620.

Lunate with concave, slightly gibbous ventral margin, 40–68 $\mu$ long, 13–15 $\mu$ wide (according to *Cleve Syn. Nav. Diat., I, p. 173,* up to 160 $\mu$ long and 25 $\mu$ wide); raphe arcuate, bent toward the ventral margin near the central nodule, ends bent toward the dorsal side; striations extending nearly to the raphe, 6–9 in 10 $\mu$ on the dorsal side in the middle, closer elsewhere; striations interrupted on the ventral side of the central nodule, leaving a row of two to five dots. These dots are mentioned in all descriptions as characteristic of the species and are found in Nebraska specimens, but do not appear in Rabenhorst's specimens, *Alg. Eu., 1028.*

In rivers, ponds, lakes, etc., also fossil: Anselmo, Bellevue, Big Alkali Lake, Broken Bow, Cedar Creek, Crawford, Dewey Lake, Dismal River, Dunning, Gordon Creek, Grand Island, Hackberry Lake, Long Pine, Pelican Lake, St. Paul, Seneca, South Bend, Trenton, Valentine, Wahoo.

Fossil: Agate, Greeley County, Loup City, Merriman, Mullen, Spalding, Thedford, Wheeler County.

Blackpipe, S. Dak.; Devils Lake, N. Dak.; Ft. Collins, Colo.

14. **Cymbella helvetica** Kütz. *Bacill., p. 79, pl. 6, fig. 13. 1844.*
Pl. 16, fig. 621.

Lanceolate with dorsal margin convex, ventral margin slightly concave but swollen in the middle, 36–88 μ long, 10–15 μ wide; raphe nearly straight but slightly curved, the ends at the central nodule bent toward the ventral margin; raphe surrounded by a narrow hyaline space which at the center is widened to about one-third the width of the valve; terminal nodules elongated; striations distinct, 8–9 in 10 μ.

In White River, Andrews.
Fossil: Agate.

## 31. Encyonema

**Encyonema** Kütz. *Syn. Diat., p. 61. 1834.*

Etym., from Gr. ἔγκυος, pregnant, and νήμα, thread, the cells being connected by a gelatinous mass into threads.

Cells usually enclosed in gelatinous tubes; like *Cymbella* in outline; raphe straight; terminal nodules somewhat distant from the ends. Chromatophores and auxospores as in *Cymbella*.

*A.* Terminal nodules distant from the ends of the valves. 1. *E. prostratum.*
*AA.* Terminal nodules nearer the ends of the valves.
*b.* Striations coarsely granular. 2. *E. turgidum.*
*bb.* Striations finely granular. 3. *E. ventricosum.*

1. **Encyonema prostratum** (Berk.) Kütz. *Bacill., p. 82, pl. 25, fig. 7. 1844.*
*Monema prostratum* Berk. *Brit. Alg., pl. 4, fig. 3. 1833.*
Pl. 17, figs. 622–624.

Roughly lunate, 40–100 μ long, 19–30 μ wide, dorsal margin very convex, ventral margin nearly straight, more or less gibbous; apices blunt, usually bent toward the ventral side; raphe straight, not reaching to the ends of the valve; striations radiate, often converging or parallel at the ends, 7–10 in 10 μ, extending nearly to the raphe, those in the middle of unequal length, leaving a wider space. Fig. 624 is drawn from specimen in *Rabenh. Alg. Eu., 1208.*

In springs, creeks, rivers, etc., usually with *Spirogyra* or similar algae:

Culbertson, Dismal River, Dunning, Fairbury, O'Neill, Tekamah, St. Paul, Thedford.

Fossil: Agate, Hay Springs, Loup City, Thedford.

Rapid City, S. Dak.; Ft. Collins, Colo.

2. **Encyonema turgidum** (Greg.) Grun. in *A. Schm. Atl., pl. 10, figs. 40–53. 1874.*

*Cymbella turgida* Greg. in *Mic. Jour., p. 5, pl. 1, fig. 18. 1856.*

Pl. 17, figs. 625–627.

Lanceolate, 50–100 $\mu$ long, 12–23 $\mu$ wide, dorsal margin very convex, ventral margin nearly straight or more or less convex, apices acute; raphe straight, about twice as far from the dorsal as from the ventral margin; terminal nodules near the ends; striations nearly perpendicular to the margins or slightly converging at the ends on the ventral side, 7–9 in 10 $\mu$, rather coarsely granular, extending nearly to the raphe, leaving a distinct but narrow space along the raphe, only slightly wider in the center.

In creeks, rivers, lakes, ponds, etc., with *Spirogyra, Vaucheria; Conferva,* or *Oscillatoria,* also fossil: Arago, Ashland, Auburn, Benkleman, Bratton, Brock, Broken Bow, Central City, Culbertson, Dewey Lake, Dismal River, Emerald, Fremont, Grand Island, Long Pine, North Platte, Orleans, Pleasant Dale, Ruby, St. Michael, St. Paul, Scottsbluff, Seneca, Seward, Snake River, South Bend, Talmage, Trenton, Valentine, Wahoo, Weeping Water, West Point, Whitman.

Fossil: Agate, Cherry County, Mullen, Thedford.

Cheyenne, Wyo.; Blackpipe, Rapid City, S. Dak.; Stockton, Cal.; Emporia, Kansas.

3. **Encyonema ventricosum** (Ag.) Grun. in *Kirchn. Alg. Schles., p. 189. 1878.*

*Cymbella ventricosa* Ag. *Consp., I, p. 9. 1830.*

*Encyonema caespitosum* Kütz. *Spec. Alg., p. 61. 1849.*

Pl. 17, figs. 628–629.

Naviculoid, 15–36 $\mu$ long, 7–12 $\mu$ wide, dorsal margin much more convex than the ventral, which is often gibbous; apices slightly acute, often bent toward the ventral side; raphe straight; terminal nodules near the ends of the valves; striations nearly perpendicular to the margins of the valves, 9–16 in 10 $\mu$, extending nearly to the raphe, leaving a very narrow axial area. Fig. 629 is from Rabenhorst's *Alg. Eu., 1636.*

In creeks, rivers, lakes, etc., also fossil: Andrews, Burge, Crawford, Grand Island, Hackberry Lake, Haigler, Long Pine, New Helena, Norfolk, North Platte, Seneca, Thedford, Valentine.

Fossil: Agate, Mullen, Valentine.

Belvidere, Rosebud, Weta, S. Dak.; Cheyenne, Wyo.; Blackhand, Granville, Rio Grande, Ohio.

## 32. Amphora

*Amphora* Ehr. in *Ber. Berl. Akad., p. 205. 1840.*

*Okedenia* Euelenstein.

Etym., *amphora*, a Roman water jar, from a fancied resemblance to this vessel.

Cells single, mostly free, elliptical or rectangular in girdle view, sometimes with cuneate interzones; valves lunate, not symmetrical; raphe excentric, near the concave margin, doubly arcuate; central nodule round or transversely elongated; surface transversely punctate-striate. Chromatophore a single plate lying next to the concave side of the valves and folding back, lining both valves. Auxospores two from two mother cells.

| | |
|---|---|
| *A.* Freshwater species. | 1. *A. ovalis.* |
| *AA.* Salt water species. | |
| b. Small forms. | 2. *A. salina.* |
| *bb.* Large forms. | 3. *A. proteus.* |

1. **Amphora ovalis** Kütz. *Bacill., p. 107, pl. 5, figs. 35, 39. 1844.*

*Frustulia ovalis* Kütz. *Syn. Diat., p. 11, fig. 5. 1834.*

Pl. 17, figs. 630–643.

Cells oval, 20–84 $\mu$ long, 10–16 $\mu$ wide, inflated in the middle, apices truncate; valves lunate with acute ends; raphe close to the ventral margin; striations punctate, 8–16 in 10 $\mu$. Very variable and presenting several forms or varieties.

Very common, usually epiphytic on other algae, also fossil: Alma, Andrews, Anselmo, Ashland, Auburn, Bellevue, Benkleman, Big Alkali Lake, Battle Creek, Broken Bow, Brownlee, Burge, Central City, Chadron, Clear Lake, Cody Lake, Crawford, Culbertson, Dewey Lake, Dunning, Emmett, Fairbury, Fremont, Gordon Creek, Grand Island, Halsey, Hackberry Lake, Haigler, Holt County, Humboldt, Hyannis, Lakeside, Lincoln, Little Alkali Lake, Lodi, Long Pine, Milford, New Helena, North Platte, Northport, Oakdale, Omaha, O'Neill, Orella, Orleans, Phalaris Lake, Pleasant Dale, Plattsmouth, Red Cloud, Ruby, Rupert, St. Michael, St. Paul, Salem,

Scottsbluff, Seneca, Sheridan County, Snake River, South Bend, Stanton, Stromsburg, Talmage, Tekamah, Tioga, Thedford, Trenton, Valentine, Wann, Watts Lake, Weeping Water, West Point, Whitman, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Loup City, Merriman, Mullen, Spalding, Thedford, Valentine, Williams's Canyon.

Belvidere, Blackpipe, Cutmeat, Little White River, Norris, Rapid City, Rosebud, Weta, S. Dak.; Devils Lake and fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Fresno, Stockton, Cal.; Ft. Collins, Colo.; Blackhand, Granville, Put-in Bay, Rio Grande, Ohio; Emporia, Kansas.

2. **Amphora salina** W. Sm. *Brit. Diat., I, p. 19, pl. 30, fig. 251. 1853.*

Pl. 17, fig. 644.

Cells elliptic-oblong with ends slightly attenuate, 21–50 $\mu$ long, 3–5 $\mu$ wide; valves lunate with rostrate, slightly capitate ends; ventral margin often nearly straight; striations fine, granular, 18–21 in 10 $\mu$.

In basin of salt well and in jar in laboratory, Lincoln.

3. **Amphora proteus** Greg. *Diat. of Clyde, p. 518, pl. 13, fig. 81. 1857.*

Pl. 17, fig. 645.

Cells elliptic with truncate ends, 70–150 $\mu$ long, 40–60 $\mu$ wide; valves lunate, ends obtuse; raphe bent, central nodule large, often surrounded by a stauroneiform space; striations very distinct, granular, 8–10 in 10 $\mu$.

In Devils Lake, N. Dak.

## 33. Cystopleura

**Cystopleura** Breb. in *Kütz. Spec. Alg., p. 3. 1849.*

*Epithemia* Breb.; *Amphicampa* Ehr.; *Climacidium* Ehr.; *Desmogonium* Ehr.

Etym., from Gr. κύστις, vesicle, and πλευρά, rib, a name probably suggested by the clear vesicle-like appearance of the cell with the very prominent ribs.

Cells single, rarely in short chains, attached ventrally to other plants, girdle view oblong to barrel-shaped. Interzones present or absent; valves lunate, internally transversely ribbed, transversely beaded externally; raphe excentric, near the concave margin.

Chromatophores usually one or two large plates. Auxospores two from two conjugating mother cells.

*A.* Striations twice as numerous as the costae.
- *b.* Valves arcuate.
  - *c.* Striations coarsely granular. 1. *C. turgida.*
  - *cc.* Striations finely granular. 2. *C. sorex.*
- *bb.* Valves nearly straight.
  - *c.* Elongated, slightly gibbous. 3. *C. gibba.*
  - *cc.* Shorter, strongly gibbous. 4. *C. ventricosa.*

*AA.* Striations at least four times as numerous as the costae.
- *b.* Costae scarcely radiate, striations coarsely granular.
  - *c.* Costae with apices capitate in girdle view.
    - *d.* Costae close. 5. *C. ocellata.*
    - *dd.* Costae distant. 6. *C. argus.*
  - *cc.* Costae with apices not capitate in girdle view. 7. *C. zebra.*
- *bb.* Costae radiate, striations finely granular.
  - *c.* Ventral margin nearly straight. 8. *C. gibberula.*
  - *cc.* Ventral margin curved. 9. *C. musculus.*

1. **Cystopleura turgida** (Ehr.) Kuntze. *Rev. Gen. Plant., II, p. 891. 1891.*

*Navicula turgida* Ehr. *Abh., p. 64. 1830.*

*Epithemia turgida* (Ehr.) Kütz. *Bacill., p. 34, pl. 5, fig. 14. 1844.*

Pl. 17, figs. 646–648.

Arcuate, 70–195 $\mu$ long, dorsal margin more curved than the ventral, ends more or less capitate; costae distinct, perpendicular to the margins, 3.5–4 in 10 $\mu$; striations coarsely granular, 7–8 in 10 $\mu$. Very variable, hence presenting many so-called varieties. Fig. 647 agrees with var. *vertagus.*

Very common in ponds, rivers, creeks, tanks, etc., attached to filamentous algae, also fossil: Anselmo, Battle Creek, Bellevue, Brownlee, Burge, Callaway, Cedar Creek, Central City, Cody Lake, Crawford, Culbertson, Dismal River, Dunning, Johnson, Gordon Creek, Grand Island, Hackberry Lake, Haigler, Halsey, Hyannis, Holt County, Lakeside, Lodi, Long Pine, Nebraska City, New Helena, Newport, North Platte, Northport, Oakdale, Orleans, Peru, Phalaris Lake, Ruby, Rupert, St. Michael, St. Paul, Scottsbluff, Seneca, Snake River, South Bend, Stromsburg, Talmage, Tekamah, Thedford, Tioga, Valentine, Wahoo, Wann, Whitman.

Fossil: Agate, Cherry County, Greeley County, Loup City, Merriman, Mullen, Thedford, Valentine, Wheeler County.

Blackpipe, Cutmeat, Little White River, Norris, Rapid City, Redleaf, Rosebud, S. Dak.; Court Lake, fresh water near Devils Lake, N. Dak.; Stockton, Cal.; Blackhand, Ohio.

2. **Cystopleura sorex** (Kütz.) Kuntze. *Rev. Gen. Plant., II, p. 891. 1891.*

*Epithemia sorex* Kütz. *Bacill., p. 33, pl. 5, fig. XII, 5. 1844.*

Pl. 17, figs. 649–652.

Valves strongly arcuate, 24–40 $\mu$ long, 8–10 $\mu$ wide; ends usually capitate, sometimes only slightly so; costae distinct, radiate, 6–7 in 10 $\mu$; striations granular, 12–14 in 10 $\mu$; cells in girdle view long-oval, broadened in the middle.

In creeks, rivers, ponds, etc., also fossil: Cedar Creek, Peru, Rulo, St. Paul, Scottsbluff, Seneca, Valentine.

Fossil: Thedford.

Belvidere, Little White River, S. Dak.; Devils Lake, N. Dak.; Ft. Collins, Colo.

3. **Cystopleura gibba** (Ehr.) Kuntze. *Rev. Gen. Plant., II, p. 891. 1891.*

*Navicula gibba* Ehr. *Abh. 1830.*

*Epithemia gibba* (Ehr.) Kütz. *Bacill., p. 35, pl. 4, fig. 22. 1844.*

Pl. 17, figs. 653–654.

Linear, slightly curved, 85–200 $\mu$ long, 21–23 $\mu$ wide; dorsal margin slightly convex, somewhat inflated in the middle; ventral margin nearly straight; costae parallel, 6–8 in 10 $\mu$; striations granular, 12–14 in 10 $\mu$.

Very common in creeks, tanks, rivers, etc., with various algae or with diatoms only, also fossil: Anselmo, Benkleman, Big Alkali Lake, Brownlee, Burge, Central City, Clear Lake, Cody Lake, Crawford, Culbertson, Dismal River, Dunning, Fremont, Grand Island, Hackberry Lake, Haigler, Holt County, Humboldt, Ithaca, Lakeside, Long Pine, Meadow, North Platte, Oakdale, Orella, Orleans, Phalaris Lake, Ruby, Rupert, Scottsbluff, Seneca, St. Michael, St. Paul, Stanton, Talmage, Thedford, Valentine, Wahoo, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Loup City, Merriman, Mullen, Thedford, Valentine, Wheeler County.

Belvidere, Blackpipe, Cutmeat, Dallas, Imlay, Little White River, Norris, Rapid City, Rosebud, Turtle River, S. Dak.; Court Lake, Devils Lake,

fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Stockton, Cal.; Ft. Collins, Colo.; Muskingum River, Rio Grande, Ohio.

4. **Cystopleura ventricosa** (Kütz.) Elmore.

*Epithemia ventricosa* Kütz. *Bacill., p. 35, pl. 30, fig. 9. 1844.*

Pl. 17, figs. 655–657.

Elliptical, 37–75 μ long, 19–22 μ wide in girdle view, gibbous in the middle; ventral side straight or nearly so with ends more or less produced toward the ventral side; costae heavy, nearly parallel in the center, becoming more radiate toward the ends, 5.5–7 in 10 μ; striations granular, 12–14 in 10 μ. Often described as a variety of *C. gibba,* from which it differs mainly in size and in the larger inflation in the middle.

Very common in almost all places where any diatoms can grow, also fossil: Ainsworth, Anselmo, Arago, Ashland, Bellevue, Broken Bow, Brownlee, Burge, Callaway, Cedar Creek, Cherry County, Clear Lake, Crawford, Dismal River, Dunning, Emerald, Ewing, Fremont, Georgetown, Gordon Creek, Grand Island, Halsey, Holt County, Humboldt, Hyannis, Lakeside, Lodi, Long Pine, Louisville, Meadow, New Helena, Norfolk, Peru, Plattsmouth, Pleasant Dale, Red Cloud, Ruby, Rulo, St. Paul, Scottsbluff, Seneca, Snake River, South Bend, Tecumseh, Tekamah, Thedford, Valentine, Wann, West Point, Whitman, Woodlake.

Fossil: Cherry County, Mullen, Thedford.

Dallas, Rosebud, Turtle River, Weta, S. Dak.; Devils Lake, N. Dak.; Cheyenne, Wyo.

5. **Cystopleura ocellata** (Ehr.) Kuntze. *Rev. Gen. Plant., II, p. 891. 1891.*

*Eunotia ocellata* Ehr. *Ber., p. 15. 1840.*

*Epithemia ocellata* Kütz. *Bacill., p. 34, pl. 29, fig. 57. 1844.*

Pl. 17, figs. 658–660.

Valves lunate, 25–32 μ long, 5–6 μ wide; ends bluntly rounded or sometimes acute; costae heavy, 3–4 in 10 μ, capitate in girdle view; striations granular, 12–20 in 10 μ.

In creeks, lakes, rivers, etc., also fossil: Anselmo, Benkleman, Brownlee, Burge, Crawford, Culbertson, Dismal River, Dunning, Emmett, Grand Island, Hackberry Lake, Haigler, Halsey, Lakeside, Long Pine, New Helena, North Platte, Red Cloud, Rupert, St. Michael, St. Paul, Scottsbluff, Seneca, Snake River, Stanton, Tioga, Valentine.

Fossil: Agate, Loup City, Mullen, Thedford.

Little White River, Rosebud, S. Dak.; Cheyenne, Wyo.; fresh water near Devils Lake, N. Dak.; Stockton, Cal.

6. **Cystopleura argus** (Kütz.) Kuntze. *Rev. Gen. Plant., II, p. 891. 1891.*

*Epithemia argus* Kütz. *Bacill., pl. 29, fig. 55. 1844.*

Pl. 17, fig. 661; pl. 23, figs. 850–855.

Dorsal margin slightly arcuate, ventral margin nearly straight, 40–70 μ long, apices obtuse; costae slightly radiate with capitate apices, 1–2 in 10 μ; striations granular, 10–14 in 10 μ.

Lakeside, Woodlake.
Fossil: Hay Springs, Merriman.
Fresh water near Devils Lake, N. Dak.

7. **Cystopleura zebra** (Ehr.) Kuntze. *Rev. Gen. Plant., II, p. 891. 1891.*

*Navicula zebra* Ehr. *Abh., p. 262. 1833.*

*Epithemia zebra* (Ehr.) Kütz. *Bacill., p. 34, pl. 5, fig. 12; pl. 30, fig. 5. 1844.*

Pl. 17, figs. 662–667.

Curved, 35–70 μ long, 8–12 μ wide; dorsal margin strongly convex, ventral more or less concave; apices somewhat capitate; pseudoraphe distinct, incurved, forming an angle at the center; costae heavy, 3–4 in 10 μ; striations coarsely granular, 12–14 in 10 μ. Var. *proboscidea* is a more curved form.

In creeks, rivers, ponds, etc., also fossil: Benkleman, Burge, Clear Lake, Crawford, Dismal River, Dunning, Gibbon, Grand Island, Halsey, Holt County, Hyannis, Lakeside, St. Paul, Seneca, Snake River, South Bend, Talmage, Thedford, Trenton, Valentine, Wann.

Fossil: Agate, Cherry County, Hay Springs, Loup City, Merriman, Mullen, Thedford.

Blackpipe, Cutmeat, Norris, S. Dak.; Court Lake, Devils Lake, N. Dak.; Ft. Collins, Colo.; Stockton, Cal.

8. **Cystopleura gibberula** (Kütz.) Kuntze. *Rev. Gen. Plant., II, p. 891. 1891.*

*Epithemia gibberula* Kütz. *Bacill., p. 35, pl. 29, fig. 54; pl. 30, fig. 3. 1844.*

Pl. 17, figs. 668–669.

Valves strongly lunate, 20–70 μ long; dorsal margin very strongly curved, ventral margin nearly straight, gradually tapering

toward the acute ends; costae 3–4 in 10 $\mu$, radiate; striations granular, about 16 in 10 $\mu$; in girdle view broadly elliptical to lanceolate-elliptical. Var. *producta* Grun. is a smaller form with ends of valves attenuate.

In creeks, etc.: Crawford, Fremont, Grand Island, Norfolk, Valentine, Woodlake.

Fossil: Hay Springs.

9. **Cystopleura musculus** (Kütz.) Kuntze. *Rev. Gen. Plant., II, p. 891. 1891.*

*Epithemia musculus* Kütz. *Bacill., p. 33, pl. 30, fig. 6. 1844.* Pl. 17, figs. 670–671.

Valves nearly semicircular, 27–50 $\mu$ long, 7–9 $\mu$ wide; dorsal margin strongly convex, ventral margin concave; ends acute and somewhat produced; costae radiate, about 4 in 10 $\mu$; striations granular, about 16 in 10 $\mu$; in girdle view broadly elliptical.

In creeks, lakes, ponds, etc., also fossil: Anselmo, Ashland, Clear Lake, Crawford, Emerald, Fremont, Grand Island, Lakeside, New Helena, Orleans, Pleasant Dale, Ruby, Rupert, Scottsbluff, Stanton, Talmage, Thedford, Trenton, Valentine.

Fossil: Cherry County.

Blackpipe, Little White River, Turtle River, S. Dak.; Cheyenne, Wyo.

## Family 7. BACILLARIACEAE

Cells usually very much broader than long (rod-like), usually free-swimming, but some enclosed in gelatinous tubes and a few adhering in filaments. Rachis lateral, hence not interrupting the fine striations; containing an elongated slit.

### 34. **Homoeocladia** (*Nitzschia*)

**Homoeocladia** Ag. *Flora, II, p. 629. 1827.*

Etym., from Gr. ὅμοιος, similar, and κλάδος, branch, from the fact that some of the species to which the name was first given grow in branching tubes of uniform diameter.

*Nitzschia* Hassall. *Brit. Freshw. Algae, p. 435. 1845. Grunowia* Rabenh.; *Oscillaria* Schrank.; *Pritchardia* Rabenh.; *Sigmatella* Kütz.

Cells mostly free, rarely in tubes or chains, sometimes stalked; elongated or linear, rhombic in cross-section; valves linear to lanceolate or elliptical, pointed, with the oblique, bordered keel at

one edge enclosing the raphe; keels of the two valves on the opposite sides of the cell except in the subdivision *Hantzschia*, where they are on the same side; surface punctate-striate, usually transversely, decussate in some species. Chromatophore one large plate with an entire or partial fissure and with one or many small pyrenoids lying next to the girdle side.

TABLE OF GROUPS

*A*. Not long-rostrate.
*b*. Keels of the two valves on the same side of the cell.
1. *Hantzschia*, page 132.
*bb*. Keels of the two valves diagonally opposite.
*c*. Valves undulate. 2. *Tryblionella*, page 133.
*cc*. Valves not undulate.
*d*. With costae extending partly across the valves or carinal dots prolonged into delicate costae.
3. *Grunowia*, page 134.
*dd*. Carinal dots not prolonged into costae.
*e*. Cells more or less sigmoid.
*f*. Keel straight, not inflected in the middle.
*g*. Keel almost central; girdle face with apices not attenuate. 4. *Sigmoideae*, page 135.
*gg*. Keel excentric; girdle face with apices slightly attenuate. 5. *Sigmata*, page 137.
*ff*. Keel excentric; inflected in the middle.
6. *Obtusae*, page 137.
*ee*. Cells not sigmoid.
*f*. Cells arcuate. 7. *Spectabiles*, page 138.
*ff*. Cells not arcuate.
*g*. Girdle face constricted in the middle.
8. *Dubiae*, page 138.
*gg*. Girdle face not constricted in the middle.
*h*. Valves showing a longitudinal sulcus in which the striations are either absent or indistinct. 9. *Apiculatae*, page 139.
*hh*. No longitudinal sulcus.
*i*. Keel excentric.
10. *Lanceolatae*, page 140.
*ii*. Keel not entirely excentric.
*j*. Keel almost central; striations very distinct, cells united in a plate.
11. *Bacillaria*, page 143.
*jj*. Keel somewhat excentric; cells not united.

*k*. Valves linear, large, striations distinct.
12. *Lineares*, page 143.
*kk*. Valves lanceolate, small, striations indistinct.
13. *Dissipatae*, page 144.
*AA*. Valves long-rostrate with very excentric keel.
14. *Nitschiella*, page 145.
*AAA*. Cells in a gelatinous tube. 15. *Homoeocladia*, page 145.

### 1. Hantzschia

*A*. Carinal dots not elongated. 1. *H. amphioxys*.
*AA*. Carinal dots elongated. 2. *H. virgata*.

1. **Homoeocladia amphioxys** (Ehr.) Kuntze. *Rev. Gen. Plant., III, p. 408. 1898.*
*Hantzschia amphioxys* (Ehr.) Grun. in *Cl. & Grun. Arct. Diat., p. 103. 1880.*
*Eunotia amphioxys* Ehr. *Amer., p. 125. 1843.*
Pl. 18, figs. 672–680.

More or less curved, 34–192 μ long, 10–18 μ wide; apices more or less rostrate; carina marginal with 4–7 round dots in 10 μ, the two central dots slightly more separated, carinae of the two valves on the same side of the cell, fig. 680; striations granular, 10–15 in 10 μ. Very variable and presenting several forms called varieties. Var. *major*, figs. 672, 674; var. *elongata*, fig. 673; var. *vivax*, figs. 675, 679.

Very common under all conditions where any diatoms can grow; creeks, springs, ponds, rivers, tanks, stagnant ditches, etc., also fossil: Ainsworth, Anselmo, Benkleman, Brock, Broken Bow, Brownlee, Burge, Central City, Cherry County, Clear Lake, Columbus, Crawford, Culbertson, Dismal River, Dunning, Emerald, Gordon Creek, Grand Island, Hackberry Lake, Haigler, Halsey, Hemingford, Holbrook, Holt County, Hyannis, Ithaca, Lakeside, Lincoln, Lodi, Long Pine, Louisville, Milford, New Helena, Norfolk, North Platte, Oakdale, O'Neill, Orella, Orleans, Pelican Lake, Peru, Pleasant Dale, Red Cloud, Ruby, Rupert, St. Libory, St. Michael, St. Paul, Seneca, Seward, Sheridan, County, Snake River, Stanton, Talmage, Tekamah, Thedford, Trenton, Valentine, Wann, Watts Lake, Weeping Water, West Point, Whitman, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Loup City, Mullen, Thedford, Valentine, Wheeler County.

Belvidere, Blackpipe, Imlay, Interior, Little White River, Norris, Redleaf, Rosebud, Scenic, Turtle River, Weta, S. Dak.; Devils Lake, fresh water near Devils Lake, N. Dak.; Cheyenne, Wyo.; Stockton, Cal.; New Concord, Rio Grande, Ohio.

2. **Homoeocladia virgata** (Roper) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Hantzschia virgata* (Roper) Grun. in *Cl. & Grun. Arct. Diat., p. 104. 1880.*

*Nitzschia virgata* Roper in *Mic. Jour., VI, p. 23. 1858.*

Pl. 18, fig. 681.

Robust, arcuate, 66–130 $\mu$ long, 13–20 $\mu$ wide, apices strongly rostrate, obtuse, keels of the two valves on the same side of the cell, with elongated dots, 4–5 in 10 $\mu$, the two central dots slightly more separated; striations 9–11 in 10 $\mu$.

In pond, Orella.

2. TRYBLIONELLA

*A.* Striations composed of coarse puncta. 3. *H. punctata.*
*AA.* Striations not of coarse puncta.
*b.* Striations extending across the entire valve. 4. *H. angustata.*
*bb.* Striations interrupted by a sulcus. 5. *H. tryblionella.*

3. **Homoeocladia punctata** (W. Sm.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia punctata* (W. Sm.) Grun. in *Cl. & Grun. Arct. Diat., p. 68. 1880.*

*Tryblionella punctata* W. Sm. *Brit. Diat., I, p. 36, pl. 30, fig. 261. 1853.*

Pl. 18, figs. 682–686.

Elliptical to elliptical-lanceolate, 25–40 $\mu$ long, 7–30 $\mu$ wide, apices acute or acuminate; keel marginal with the dots corresponding with the striations, which are formed of coarse dots, 7–10 in 10 $\mu$.

Ponds: Pleasant Dale, Grand Island.
Fossil: Thedford.

4. **Homoeocladia angustata** (W. Sm.) Kuntze. *Rev. Gen. Plant., III, p. 408. 1898.*

*Nitzschia angustata* (W. Sm.) Grun. in *Cl. & Grun. Arct. Diat., p. 70. 1880.*

*Tryblionella angustata* W. Sm. *Brit. Diat., I, p. 36, pl. 30, fig. 262. 1853.*

Pl. 18, figs. 687–691.

Narrowly linear to ovate-lanceolate, 80–90 μ long, about 10 μ wide, apices attenuate; keel marginal, dots corresponding with the striations, about 13 in 10 μ. The form described as var. *curta* is smaller, 48–67 μ long, 7–11 μ wide.

In creeks, ponds, etc.: Culbertson, Fremont, Grand Island, Norfolk, North Platte, Ruby, Trenton, West Point.

5. **Homoeocladia tryblionella** (Hantz.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia tryblionella* Hantz. in *Rabenh. Alg., No. 984. 1871.*

Pl. 18, figs. 692–698.

From elliptical to lanceolate, 20–110 μ long, 6–30 μ wide, apices more or less acute; valves undulate with a sulcus making the striations appear broken; keel marginal with indistinct dots elongated to form costae or striations, 7–12 in 10 μ, very fine punctate striations mixed with the coarser striations. Var. *levidensis* is a form more elongated and with finer striations, fig. 693. Very variable. Grunow in *Cl. & Grun. Arct. Diat., p. 69,* says: "This widely distributed species includes a very large number of forms among which it is very difficult to separate a single variety with certainty as is here attempted. They vary in respect to form, length, and width, the undulation of the valves, the distinct or indistinct punctation of the very variable striations which sometimes are very much fainter in the middle than near the margins and sometimes equally distinct over the entire valve. Many valves appear strongly costate and many punctate with only indistinct striations."

Common among higher algae where conditions are good: Alma, Arbor, Ashland, Auburn, Blue Springs, Cherry County, Crawford, Culbertson, Fairbury, Fremont, Grand Island, Hackberry Lake, Lincoln, Nemaha City, North Platte, Omaha, Orleans, Pleasant Dale, Ruby, Rupert, St. Paul, Stanton, Stromsburg, Talmage, Tekamah, Wahoo, Wann, Weeping Water.

Belvidere, Rapid City, Rosebud, S. Dak.; Court Lake, Devils Lake, fresh water near Devils Lake, N. Dak.; Stockton, Cal.

### 3. Grunowia

*A.* Valves with sinuous margins. 6. *H. tabellaria.*

*AA.* Margins of valves not sinuous. 7. *H. obtusa.*

6. **Homoeocladia tabellaria** (Grun.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Denticula tabellaria* Grun. in *Wien. Verh., p. 548. 1862.*

*Nitzschia tabellaria* Grun. in *Cl. & Grun. Arct. Diat., p. 82. 1880.*

*Nitzschia sinuata* (W. Sm.) Grun. in *Cl. & Grun. Arct. Diat., p. 82. 1880.*

*Denticula sinuata* W. Sm. *Brit. Diat., II, p. 21. 1856.*

Pl. 18, fig. 699.

Lanceolate with margins undulate, very much inflated in the middle, 26–30 μ long, 7–10 μ wide, apices small, globose; keel marginal with dots elongated into costae extending about to the middle of the valve, 5–6 in 10 μ; striations 18–20 in 10 μ. The specimen represented in fig. 699 seems intermediate between *Nitzschia sinuata* (W. Sm.) Grun. and *Nitzschia sinuata* var. *tabellaria* Grun. as figured in *V. H. Diat., pl. 15, figs. 516, 517.*

Fossil in limestone: Mullen.

7. **Homoeocladia obtusa** (Lyngb.) Elmore.

*Echinella obtusa* Lyngb. *Hydrophyt. Dan., pl. 69. 1819.*

*Frustulia obtusa* Ag. *Consp., p. 44. 1830.*

*Nitzschia denticula* Grun. in *Cl. & M. Diat. Exsic., No. 224. 1878.*

Pl. 18, figs. 700–706.

Narrowly lanceolate, 14–86 μ long, 6–9 μ wide, apices more or less acute, not rostrate; keel marginal with dots elongated into costae which extend from half across the valve to entirely across, 4–8 in 10 μ; striations granular, 14–18 in 10 μ.

In tanks, rivers, creeks, etc.: Crawford, Long Pine, Louisville, North Platte, O'Neill, Rupert, Seneca, Stromsburg, Valentine.

Fossil: Agate.

Cheyenne, Wyo.; Blackpipe, S. Dak.; Stockton, Cal.

## 4. Sigmoideae

*A.* Striations distinct; carinal dots round. 8. *H. brebissonii.*

*AA.* Striations fine; carinal dots somewhat elongated.

*b.* Very large; dots 4–7 in 10 μ. 9. *H. sigmoidea.*

*bb.* Medium size; dots 7–9 in 10 μ. 10. *H vermicularis.*

8. **Homoeocladia brebissonii** (W. Sm.) Kuntze. *Rev. Gen. Plant., III, p. 408. 1898.*

*Nitzschia brebissonii* W. Sm. *Brit. Diat., I, p. 38, pl. 31, fig. 266. 1853.*

Pl. 18, fig. 710.

Straight, arcuate, or sigmoid, 220–345 μ long, 12–15 μ wide, apices attenuate, sometimes capitate; keel central with coarse dots, 4–5 in 10 μ; striations 9–11 in 10 μ.

Clear Lake, Grand Island, St. Paul, Snake River.
Fossil: Agate.

9. **Homoeocladia sigmoidea** (Nitz.) Elmore.

*Nitzschia sigmoidea* (Nitz.) W. Sm. *Brit. Diat., I, p. 38. 1853.*

*Bacillaria sigmoidea* Nitz. *Beitr., p. 104. 1817.*

Pl. 18, figs. 708–709.

Linear or lanceolate with cuneate apices, 100–480 μ long; keel nearly central with rounded dots, 4–8 in 10 μ; striations 24–30 in 10 μ; girdle face sigmoid, linear, or somewhat lanceolate with truncate apices.

In ponds, creeks, etc.: Grand Island, Lincoln, Orella.
New Concord, Ohio.

10. **Homoeocladia vermicularis** (Kütz.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia vermicularis* (Kütz.) Hantz. in *Rabenh. Alg., No. 899.*

*Synedra vermicularis* Kütz. *Bacill., p. 67, pl. 4, fig. 35. 1844.*

Pl. 19, figs. 713–716.

Linear or linear-lanceolate, straight or slightly sigmoid, apices attenuate, sometimes capitate, 90–220 μ long, 4–11 μ wide; keel nearly central with slightly elongated dots, 6–10 in 10 μ; striations very delicate, 30–34 in 10 μ.

In ditches, creeks, springs, etc., also fossil: Alma, Andrews, Arago, Auburn, Blue Springs, Brock, Brownville, Clear Lake Crawford, Crete, Culbertson, Fairbury, Glen Rock, Grand Island, Holbrook, Johnson, Julian, Lincoln, Mason City, Minden, Nemaha City, New Helena, Norfolk, Omaha, Orleans, Peru, Ruby, Rulo, Salem, Stanton, Stromsburg, Talmage, Valentine, Weeping Water.

Fossil: Mullen.

Belvidere, Rapid City, Rosebud, S. Dak.; Devils Lake, N. Dak.; Stockton, Cal.; New Concord, Ohio; Emporia, Kansas.

### 5. Sigmata

*A.* Keel with coarse projecting dots. 11. *H. fasciculata.*
*AA.* Keel with rather delicate dots. 12. *H. sigma.*

11. **Homoeocladia fasciculata** (Grun.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia fasciculata* Grun. *Alg. Kasp. Meer, p. 119. 1878.*

Pl. 19, fig. 717.

More or less sigmoid, 67–95 $\mu$ long, 6–7 $\mu$ wide; keel excentric with 4–6 dots in 10 $\mu$, dots somewhat elongated; striations 28–30 in 10 $\mu$; girdle face sigmoid.

Pleasant Dale.

12. **Homoeocladia sigma** (Kütz.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia sigma* (Kütz.) W. Sm. *Brit. Diat., I, p. 39. 1853.*

*Synedra sigma* Kütz. *Bacill., p. 67, pl. 30, fig. 14. 1844.*

Pl. 19, figs. 718–724.

Linear, slightly sigmoid, 88–250 $\mu$ long, 5–11 $\mu$ wide; keel somewhat excentric with 7–9 dots in 10 $\mu$; striations 22–30 in 10 $\mu$; girdle face sigmoid with tapering apices. Variable and presenting many forms represented by var. *rigidula*, figs. 722–723; var. *rigida*, fig. 721. Very much sigmoid in var. *intercedens*, fig. 720.

In creeks, springs, ponds, etc., with *Spirogyra* and other algae: Ashland, Auburn, Dunning, Emerald, Fairbury, Grand Island, Hyannis, Julian, Lincoln, Milford, North Platte, Oakdale, Orella, Sheridan County, Stanton, Stromsburg, Tekamah, Trenton, Valentine, Wahoo.

Belvidere, Cutmeat, S. Dak.; Stockton, Cal.

### 6. Obtusae

13. **Homoeocladia arcus** (Buhln.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia arcus* Buhln. in *Hedwigia, II, p. 22, pl. 2, fig. 1. 1859.*

*Nitzschia obtusa* W. Sm. *Brit. Diat., I, p. 39, pl. 13, fig. 109. 1853.*

Pl. 23, fig. 861.

Linear, 120–300 μ long, slightly sigmoid, obtusely rounded at both ends; keel more or less excentric with 5–6 dots in 10 μ; striations 26–27 in 10 μ. No specimen yet found in Nebraska attains this size. Represented here by var. *brevissima*, which is short-linear, slightly curved and constricted in the middle, 27–28 μ long, 5–6 μ wide, with 8–10 dots and about 30 striations in 10 μ; apices apiculate.

Damp ground, tanks, creeks, etc.: Ainsworth, Anselmo, Dunning, Ewing, Grand Island, Lakeside, Long Pine, Louisville, Stromsburg, Valentine, West Point.

### 7. Spectabiles

14. **Homoeocladia spectabilis** (Ehr.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia spectabilis* (Ehr.) Ralfs in *Pritch. Inf., p. 782. 1843.*

*Synedra spectabilis* Ehr. *Verb. (figures only). 1843.*

Pl. 19, figs. 711–712.

Linear, slightly curved, 160–306 μ long, 11–15 μ wide, apices cuneate, attenuate, often rostrate; keel marginal with large dots sometimes slightly prolonged, 3–7 in 10 μ; striations 11–15 in 10 μ.

In lakes, creeks, rivers, also fossil: Ainsworth, Anselmo, Clear Lake, Dunning, Emmett, Hackberry Lake, Halsey, Long Pine, Newport, O'Neil', St. Michael, St. Paul, Thedford, Whitman.

Fossil: Agate, Cherry County, Hay Springs, Merriman, Mullen, Spalding.

Little White River, S. Dak.; fresh water near Devils Lake, N. Dak.; Stockton, Cal.

### 8. Dubiae

| | |
|---|---|
| *A.* Carinal dots elongated; valves broad. | 15. *H. dubia.* |
| *AA.* Carinal dots round; valves elongated. | |
| *b.* Small, striations fine, distinctly rostrate. | 16. *H. commutata.* |
| *bb.* Medium size, sub-rostrate. | 17. *H. umbonata.* |

15. **Homoeocladia dubia** (W. Sm.) Elmore.

*Nitzschia dubia* W. Sm. *Brit. Diat., I, p. 41, pl. 13, fig. 112.*

Pl. 19, fig. 725.

Linear, ventral side nearly straight, dorsal side slightly convex, slightly constricted in the middle, 90–160 μ long, about 15 μ wide,

apices rounded or sub-rostrate; carinal dots slightly elongated, 9–10 in 10 μ; striations fine, 20–24 in 10 μ.

In ditch by railroad: Culbertson.

16. **Homoeocladia commutata** (Grun.) Kuntze. *Rev. Gen. Plant., III, p. 408. 1898.*

*Nitzschia commutata* Grun. in *Cl. & Grun. Arct. Diat., p. 79. 1880.*

Pl. 19, figs. 726–728; pl. 23, fig. 858.

Linear, 34–73 μ long, 8–17 μ wide, constricted in the middle, apices attenuate-rostrate; keel marginal with round dots, 8–10 in 10 μ, the two middle ones more distant; striations 21–24 in 10 μ.

In ponds and creeks: Anselmo, Grand Island, Lincoln, Trenton. Devils Lake and fresh water near Devils Lake, N. Dak.

17. **Homoeocladia umbonata** (Ehr.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Navicula umbonata* Ehr. *Abh., p. 36. 1836.*

*Nitzschia thermalis* (Ehr.) Auersw. in *Rabenh. Alg., Nos. 1064 and 1266.*

Pl. 19, fig. 729.

Linear-lanceolate or oblong, 80–100 μ long, 9–10 μ wide, slightly constricted in the middle, making the cell somewhat curved, apices cuneate; keel marginal with round dots, 7–8 in 10 μ; striations about 28 in 10 μ.

Talmage.

### 9. Apiculatae

*A.* Keel with very distinct dots. 18. *H. hungarica.*
*AA.* Keel with indistinct dots. 19. *H. apiculata.*

18. **Homoeocladia hungarica** (Grun.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia hungarica* Grun. in *Wien. Verh., p. 568, pl. 22, fig. 13. 1862.*

Pl. 19, figs. 730–735.

Linear, usually constricted in the middle, 48–110 μ long, 8–11 μ wide, apices slightly acuminate, acute or truncate; keel marginal with 7–11 dots in 10 μ; striations 15–20 in 10 μ, interrupted through the middle by a longitudinal sulcus.

In creeks, springs, tanks, ponds, etc.; in brackish water at Arbor: Arbor, Ashland, Auburn, Blue Springs, Cedar Creek, Culbertson, Fairbury, Grand Island, Hyannis, Lincoln, Louisville, Oakdale, Omaha, Orleans, Ruby, Salem, Scottsbluff, Seneca, Seward, Stromsburg, Talmage, Trenton, Wann. Belvidere, Little White River, Norris, Rapid City, Rosebud, S. Dak.; Devils Lake and fresh water near Devils Lake, N. Dak.; Stockton, Cal.

19. **Homoeocladia apiculata** (Greg.) Kuntze. *Rev. Gen. Plant., III, p. 408. 1898.*

*Nitzschia apiculata* (Greg.) Grun. in *Cl. & Grun. Arct. Diat., p. 73. 1880.*

*Tryblionella apiculata* Greg. in *Mic. Jour., V, p. 79, pl. 1, fig. 3.*

Pl. 19, fig. 736.

Linear, more or less constricted in the middle and below the apices, 25–34 μ long, 6–8 μ wide, apices apiculate, sometimes truncate; keel marginal with no visible dots; striations broken by the narrow sulcus, 15–19 in 10 μ.

In jar in laboratory, Lincoln; roadside ditch, Grand Island; North Platte, Scottsbluff.

### 10. Lanceolatae

*A.* Connecting zone very broad and plicate. 20. *H. lanceolata.*
*AA.* Connecting zone narrow.
  *b.* Middle carinal dots more distant than the others.
    *c.* Striations 30–32 in 10 μ. 21. *H. subtilis.*
    *cc.* Striations about 24 in 10 μ. 22. *H. intermedia.*
  *bb.* Carinal dots all equidistant.
    *c.* Striations distinct, 16–17 in 10 μ. 23. *H. amphibia.*
    *cc.* Striations indistinct, more than 20 in 10 μ.
      *d.* Lanceolate, striations very delicate, 30–36 in 10 μ. 24. *H. palea.*
      *dd.* Narrowly lanceolate, striations more easily seen, 20–22 in 10 μ. 25. *H. frustulum.*

20. **Homoeocladia lanceolata** (W. Sm.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia lanceolata* W. Sm. *Brit. Diat., I, p. 40, pl. 14, fig. 118. 1853.*

Pl. 19, figs. 737–739.

Narrowly lanceolate, 66–200 μ long, 8–17.5 μ wide, apices acute, sometimes attenuate and rostrate; keel marginal with rounded dots,

5–8 in 10 $\mu$, the middle ones not separated more than the others; striations 24–30 in 10 $\mu$.

Grand Island, Valentine.
Devils Lake, N. Dak.; Emporia, Kansas.

21. **Homoeocladia subtilis** (Grun.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*
*Nitzschia subtilis* Grun. in *Cl. & Grun. Arct. Diat., p. 95. 1880.*
Pl. 20, fig. 740.

Narrowly lanceolate, 49–120 $\mu$ long, 4.5–9 $\mu$ wide, apices attenuate; keel marginal with dots not elongated, 7–13 in 10 $\mu$, the two middle dots more distant than the rest; striations 30–32 in 10 $\mu$; girdle face straight. The form described as var. *palcacea* is smaller and more delicate with 12–14 dots in 10 $\mu$.

In creeks, ponds, pools, etc.: Arago, Brock, Grand Island, Humboldt, Johnson, Julian, Lincoln, Louisville, Oakdale, Orleans, Peru, Pleasant Dale, Seneca, Talmage, Weeping Water.
Kadoka, S. Dak.; Put-in Bay, Ohio.

22. **Homoeocladia intermedia** (Hantz.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*
*Nitzschia intermedia* Hantz. in *Cl. & Grun. Arct. Diat., p. 95. 1880.*
Pl. 20, figs. 741–742.

Linear, slightly lanceolate, 68–100 $\mu$ long, apices attenuate, slightly rostrate; keel somewhat excentric with 8–9 dots in 10 $\mu$; striations about 24 in 10 $\mu$.

With *Oscillatoria* in springs, marshes, watering troughs, stagnant pools, etc.: Dawson, Long Pine, Peru, Salem.
Fossil: Loup City.

23. **Homoeocladia amphibia** (Grun.) Kuntze. *Rev. Gen. Plant., III, p. 408. 1898.*
*Nitzschia amphibia* Grun. in *Wien. Verh., p. 574. 1862.*
Pl. 20, figs. 743–751.

Linear or ovate-lanceolate, usually attenuate, apices usually rounded, sometimes slightly capitate, 14–60 $\mu$ long, 3.3–8 $\mu$ wide; keel marginal with round dots, 6–8 in 10 $\mu$; striations distinct, 12–17 in 10 $\mu$; cells sometimes united in bands like *Fragilaria*.

Very common in tanks, creeks, springs, ponds, etc., usually with some of the higher algae. Filamentous forms were found in jar in laboratory in Lincoln and in Blue River at Seward: Andrews, Anselmo, Ashland, Auburn, Battle Creek, Benkleman, Brock, Broken Bow, Brownlee, Burge, Callaway, Central City, Chadron, Clear Lake, Cody Lake, Crawford, Culbertson, Dismal River, Dunning, Fairbury, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Humboldt, Hyannis, Lakeside, Lodi, Long Pine, Louisville, Melia, Newport, North Platte, Northport, O'Neill, Orella, Orleans, Phalaris Lake, Pleasant Dale, Polk, Red Cloud, Ruby, Rupert, St. Deroin, St. Michael, St. Paul, Scottsbluff, Seneca, Snake River, Stanton, Stromsburg, Talmage, Tioga, Trenton, Valentine, Wann, Weeping Water, West Point, Whitman, Woodlake.

Fossil: Agate, Cherry County, Greeley County, Hay Springs, Mullen, Spalding, Thedford, Valentine.

Cutmeat, Dallas, Kadoka, Little White River, Norris, Rosebud, Weta, S. Dak.; Court Lake, and fresh water near Devils Lake, N. Dak.; Fresno, Cal.; Ft. Collins, Colo.; New Concord, Put-in Bay, Ohio.

24. **Homoeocladia palea** (Kütz.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia palea* (Kütz.) W. Sm. *Brit. Diat., II, p. 89. 1856.*

*Synedra palea* Kütz. *Bacill., p. 63, pl. 3, fig. 27. 1844.*

Pl. 20, figs. 752–757.

Linear or linear-lanceolate, apices acute, attenuate or often rostrate, 22–66 $\mu$ long, 2.5–5.5 $\mu$ wide; keel marginal with fine dots, 10–12 in 10 $\mu$, the middle dots not separated; striations very faint, 33–36 in 10 $\mu$. Very variable. The form represented by var. *tenuirostris,* figs. 752–753, is common.

Very common especially in stock tanks, ditches, etc., usually with blue-green algae, also fossil: Ainsworth, Alma, Andrews, Anselmo, Antioch, Ashland, Aspinwall, Atkinson, Battle Creek, Bellevue, Benkleman, Brock, Broken Bow, Brownlee, Cairo, Callaway, Cedar Creek, Central City, Cherry County, Clear Lake, Columbus, Cook, Crawford, Crete, Culbertson, Dawson, Dewey Lake, Dunning, Emerald, Fairbury, Fremont, Gibbon, Gordon Creek, Grand Island, Hackberry Lake, Haigler, Halsey Hemingford, Holbrook, Humboldt, Hyannis, Ithaca, Johnson, Lakeside, Lincoln, Long Pine, Mason City, Milford, New Helena, Niobrara River in Holt County, Norfolk, North Platte, Oakland, Omaha, O'Neill, Pawnee City, Pelican Lake, Peru, Red Cloud, Ruby, Rupert, St. Deroin, St. Libory, St. Michael, St. Paul, Salem, Seneca, Sheridan County, Snake River, Stromsburg, Talmage, Tecumseh, Tekamah, Thedford, Trenton, Valentine, Wahoo, Weeping Water, West Point.

Fossil: Hay Springs.

Belvidere, Corn Creek, Little White River, Rapid City, Redleaf, Scenic, Weta, S. Dak.; Devils Lake and fresh water near Devils Lake, N. Dak.; Stockton, Cal.; Blackhand, Muskingum River, Ohio.

25. **Homoeocladia frustulum** (Kütz.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia frustulum* (Kütz.) Grun. in *Cl. & Grun. Arct. Diat., p. 98. 1880.*

*Synedra frustulum* Kütz. *Bacill., p. 63, pl. 30, fig. 77. 1844.*

Pl. 20, figs. 758–760.

Linear or ovate-lanceolate, usually attenuate, sometimes slightly capitate, 18–40 $\mu$ long, 4–7 $\mu$ wide; keel marginal with round dots, 9–12 in 10 $\mu$; striations distinct, 20–24 in 10 $\mu$. The form described as var. *perpusilla* is found, fig. 759.

Ponds, creeks, etc.: Burge, Dismal River, Grand Island, Lincoln.

### 11. Bacillaria

26. **Homoeocladia paxillifer** (Müller) Elmore.

*Vibrio paxillifer* Müller. *Inf., p. 54, pl. 7, figs. 3–7. 1786.*

*Bacillaria paradoxa* Gmel. in *Linn. Syst. Nat., ed. 12, VI. 1788.*

*Nitzschia paradoxa* (Gmel.) Grun. in *Cleve & Grun. Arct. Diat., p. 85. 1880.*

Pl. 20, figs. 761–763.

Linear, 60–158 $\mu$ long, 3–6 $\mu$ wide, apices attenuate, slightly rostrate; carina nearly central with 6–8 round dots in 10 $\mu$; striations 17–24 in 10 $\mu$. Cells united in a stratum and moving back and forth longitudinally past one another (fig. 761).

In fresh and brackish water: Crete, Lincoln, Louisville, North Platte. Fresh water near Devils Lake, N. Dak.; Stockton, Cal.; Emporia, Kansas.

### 12. Lineares

*A.* 8–12 faint carinal dots in 10 $\mu$; valve with slight inflection in the middle. 27. *H. linearis.*

*AA.* 5–7 distinct carinal dots in 10 $\mu$; no median inflection. 28. *H. vitrea.*

27. **Homoeocladia linearis** (Ag.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia linearis* (Ag.) W. Sm. *Brit. Diat., I, p. 39, pl. 13, fig. 110. 1853.*

*Frustulia linearis* Ag. *"ex spec. authen. quae misit Dr. Greville," W. Sm., l.c.*

Pl. 20, figs. 764–765; pl. 23, fig. 859.

Linear, 70–180 μ long, 5–6 μ wide, sometimes with a constriction in the middle, apices attenuate, rostrate or capitate; keel somewhat excentric with 8–12 dots in 10 μ; striations indistinct, 22–24 in 10 μ. The form represented by var. *tenuis,* fig. 765, resembles the type, but is smaller and has finer striations, about 30 in 10 μ.

In creeks with *Oscillatoria, Spirogyra, Vaucheria,* etc.: Andrews, Fairbury, Grand Island, Humboldt, Lincoln, Talmage, Wahoo, Weeping Water. Fresno, Cal.

28. **Homoeocladia vitrea** (Norm.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia vitrea* Norm. in *Jour. Mic. Soc., IX, p. 7. 1861.*

Pl. 20, figs. 766–768.

Linear-lanceolate, often tapering more on one margin than the other, 50–130 μ long; keel somewhat excentric with large square or rounded dots, 5–8 in 10 μ; striations 20–22 in 10 μ. The form described as var. *recta* is smaller and more linear with more rounded apices and finer striations, fig. 768.

In creeks and ponds with *Spirogyra or Hormiscia*: Arago, Auburn, Fairbury, Orella, Peru, Scottsbluff, Talmage, Whitman.

Fresh water near Devils Lake, N. Dak.

## 13. Dissipatae

29. **Homoeocladia dissipata** (Kütz.) Kuntze. *Rev. Gen. Plant., III, p. 409. 1898.*

*Nitzschia dissipata* (Kütz.) Grun. in *Cl. & Grun. Arct. Diat., p. 90. 1880.*

*Synedra dissipata* Kütz. *Bacill., p. 64, pl. 14, fig. 3. 1844.*

Pl. 20, figs. 769–771.

Lanceolate, 20–45 μ long, about 5 μ wide, apices attenuate, slightly rostrate; keel somewhat excentric with 6–8 dots in 10 μ; striations not distinct. Van Heurck, *Diat., p. 394,* quotes Kitton as authority for there being 14 in 10 μ.

In creek, Long Pine.

### 14. Nitzschiella

30. **Homoeocladia acicularis** (Kütz.) Kuntze. *Rev. Gen. Plant., III, p. 408. 1898.*

*Nitzschia acicularis* (Kütz.) W. Sm. *Brit. Diat., I, p. 43, pl. 15, fig. 122. 1853.*

*Synedra acicularis* Kütz. *Bacill., p. 63, pl. 4, fig. 3. 1844.*

Pl. 20, figs. 772–774.

Lanceolate, 50–85 μ long, apices attenuated into a long rostrum the length of which is very variable; keel marginal with small dots, 12–18 in 10 μ; striations not easily visible, but according to W. Sm., l.c., there are 40 in 10 μ.

Common especially with *Oscillatoria* and other blue-green algae. In salt marsh at Arbor: Arago, Arbor, Ashland, Auburn, Blue Springs, Brock, Burge, Cherry County, Fairbury, Grand Island, Humboldt, Julian, Lincoln, Rulo, Salem, Seneca, Talmage, Weeping Water.

Stockton, Cal.; Emporia, Kansas.

### 15. Homoeocladia

31. **Homoeocladia filiformis** W. Sm. *Brit. Diat., II, p. 80, pl. 55, fig. 348. 1856.*

Pl. 20, figs. 775–777.

Cells in groups of 2–4 enclosed in simple gelatinous filaments. Valves linear or lanceolate with apices more or less acute, 40–100 μ long, 4–6 μ wide; keel central with 5–7 dots in 10 μ; striations fine.

In creek, Fairbury.

## Family 8. SURIRELLACEAE

Cells free-swimming, symmetrical to the longitudinal axis, oval, elliptic, or nearly circular, in girdle view straight, spirally twisted, undulate, or saddle-shaped. Rachis a narrow, unmarked strip; valves with two lateral wing-keels, each enclosing a slit.

### 35. **Sphinctocystis** (*Cymatopleura*)

**Sphinctocystis** Hass. *Brit. Freshw. Alg., p. 436, pl. 102, fig. 3. 1845.*

*Cymatopleura* W. Sm. in *Ann. and Mag. Nat. Hist., p. 133. 1851.*

Etym., from Gr. σφιγγείν, to bind, and κύστις, cell, the species to which the name was first applied being constricted in the middle.

Cells free, oblong to linear, straight; valve surface undulate and transversely striate with a beaded keel on each margin containing the raphe; a straight pseudoraphe along the center of the valve. Chromatophores two plates lying next to the valves. Auxospore one from two cells.

*A.* Broadly elliptical or elliptic-lanceolate. 1. *S. elliptica.*
*AA.* Linear with apices usually rostrate. 2. *S. librilis.*.

1. **Sphinctocystis elliptica** (Kütz.) Kuntze. *Rev. Gen. Plant., III, p. 431. 1898.*

*Cymatopleura elliptica* (Kütz.) W. Sm. in *Ann. and Mag. Nat. Hist., p. 133. 1851.*

*Surirella elliptica* Kütz. *Bacill., p. 61, pl. 28, fig. 28. 1844.*

Pl. 20, fig. 778.

Elliptical or elliptical-lanceolate, sometimes slightly constricted in the middle, 70–140 μ long, marginal costae short, resembling beads, 3–4 in 10 μ; striations delicate, about 18 in 10 μ; valves undulate, showing 4 or 5 depressions. The spiral form mentioned by Wolle, *Diat. of N. A., pl. 108, fig. 6,* occurs quite commonly mixed with the normal form and is evidently only an abnormal form of it. It is found also in fossil material from Mullen.

In creeks, rivers, ponds, springs, etc., usually where conditions are especially favorable for algae, also fossil: Broken Bow, Callaway, Central City, Crawford, Fremont, Grand Island, Julian, Nemaha City, New Helena, North Platte, Orleans, Plattsmouth, Ruby, St. Paul, Seneca, Talmage, Thedford, Valentine, Wann, Weeping Water.

Fossil: Hay Springs, Mullen, Valentine.

Blackpipe, Little White River, Rapid City, Rosebud, S. Dak.; Cheyenne, Wyo.; Stockton, Cal.; Emporia, Kansas.

2. **Sphinctocystis librilis** (Ehr.) Hass. *Brit. Freshw. Alg., p. 436, pl. 102, fig. 3. 1845.*

*Navicula librilis* Ehr. *Inf., p. 185. 1838.*

*Cymatopleura solea* (Breb.) W. Sm. in *Ann. and Mag. Nat. Hist., p. 12, pl. 3, fig. 9. 1851.*

*Surirella solea* Breb. *Consid., p. 17. 1838.*

*Frustulia quinquepunctata* Kütz. in *Linnaea, p. 554. 1833.*
Pl. 20, figs. 779–784.

Oblong, more or less constricted in the middle, 39–169 μ long (according to De Toni, *Syll. Alg., II, p. 599,* 300 μ long), 14–31 μ wide, apices rounded or slightly apiculate; marginal beads about 8 in 10 μ; striations perpendicular to the margins, 8–9 in 10 μ, indistinct or lacking in from 2 to 4 spots in the middle of the valve; valves undulate, as is clearly seen in girdle view. Very variable, showing all gradations from the short form in fig. 780 to the long one in fig. 779.

In creeks, rivers, ponds, pools, etc., also fossil: Andrews, Anselmo, Ashland, Blue Springs, Brock, Cairo, Callaway, Crawford, Crete, Culbertson, Dismal River, Dunning, Emerald, Fairbury, Fremont, Gordon Creek, Grand Island, Johnson, Lincoln, Long Pine, Nemaha City, New Helena, Norfolk, North Platte, Oakdale, Orleans, Plattsmouth, Rulo, St. Paul, Seneca, Snake River, South Bend, Stanton, Stromsburg, Talmage, Thedford, Valentine, Wahoo, Wann, Weeping Water.

Fossil: Greeley County, Hay Springs, Loup City, Mullen, Spalding, Valentine.

Blackpipe, Little White River, Rapid City, Rosebud, S. Dak.; Devils Lake, N. Dak.; Cheyenne, Wyo.; Stockton, Cal.; Ft. Collins, Colo.; Blackhand, Muskingum River, New Concord, Ohio; Emporia, Kansas.

## 36. Surirella

**Surirella** Turpin. *Mem. Mus., p. 362, tab. 16. 1828.*
*Novilla* Heib. *Consp. Diat. Dan., p. 100. 1863. Stenopterobia* Breb.; *Suriraya* Pfitzer in *De Toni Syll. Alg., II, p. 567. 1891.*

Etym., named for Doctor Suriray of Havre, France.

Cells free or stalked, straight or twisted, in valve view cuneate, reniform, ovate, elliptical, or linear; girdle view cuneate, elliptical, oblong, or sigmoid; valves with beaded or ribbed keel on each margin containing the raphe; surface with the ribs extending from the margin toward or to the median linear or lanceolate pseudoraphe. Chromatophores and auxospores as in *Sphinctocystis.*

*A.* Valves usually plane.
  *b.* Costae extending to or nearly to the median line.
    *c.* The two apices alike.
      *d.* Small, linear-elliptic. 1. *S. linearis.*
      *dd.* Large, lanceolate. 2. *S. biseriata.*

*cc.* Ovate.
*d.* Costae extending to the median line.
*e.* Long-oval. 3. *S. saxonica.*
*ee.* Broadly oval. 4. *S. striatula.*
*dd.* Costae shortened leaving a clear space along the median line.
*e.* Costae heavy. 5. *S. robusta.*
*ee.* Costae delicate. 6. *S. elegans.*
*bb.* Costae marginal, valves sometimes twisted. 7. *S. ovalis.*
*AA.* Valves twisted into the form of a figure "8." 8. *S. spiralis.*

1. **Surirella linearis** W. Sm. *Brit. Diat., I, p. 31, pl. 8, fig. 58. 1853.*

Pl. 21, figs. 785–788.

Oblong or linear, 16–46 μ long, 8–9 μ wide, sometimes somewhat constricted in the middle, apices cuneate; costae 3–7 in 10 μ, marginal or extending almost to the pseudoraphe. The costae in this species are described as 2–3.5 in 10 μ, but otherwise specimens from Nebraska agree with the type.

Common in tanks, springs, rivers, etc.: Alma, Andrews, Arago, Ashland, Auburn, Benkleman, Blue Springs, Brock, Broken Bow, Brownlee, Cairo, Central City, Columbus, Cook, Crawford, Culbertson, Dismal River, Fairbury, Gordon Creek, Grand Island, Hackberry Lake, Lincoln, Lodi, Long Pine, Louisville, Mason City, Milford, New Helena, O'Neill, Orleans, Phalaris Lake, Ruby, St. Michael, St. Paul, Salem, Seneca, Stromsburg, Talmage, Tekamah, Thedford, Valentine, Weeping Water, West Point, York.

Belvidere, Blackpipe, Rosebud, S. Dak.; Cheyenne, Wyo.; Chippewa Falls, Wis.; Blackhand, New Concord, Rio Grande, Rodney, Ohio.

2. **Surirella biseriata** Breb. *Alg. Falaise, pl. 7. 1838.*

Pl. 21, fig. 789.

Lanceolate to elliptical, 96–170 μ long, 25–52 μ wide, apices sometimes slightly rostrate; costae very heavy, 1.75–2 in 10 μ, somewhat radiate; var. *elliptica* is a form more elliptical and smaller than the type, some specimens only 39 μ long.

In creeks, etc.: Andrews, Crawford, Oakdale, Tekamah.
Fossil: Greeley County.
Little White River, Rosebud, S. Dak.; Stockton, Cal.

3. **Surirella saxonica** Auersw. in *Rabenh. Alg. 1421.*

Pl. 21, figs. 790–792.

Long-ovate, 75–200 μ long, 25–38 μ wide; costae 1.5–3 in 10 μ, extending to the distinct pseudoraphe; striations indistinct; dried empty shells often brownish. Differs from *S. robusta* mainly in the more distinct pseudoraphe with costae extending to it.

In springs and creeks, also fossil: Aspinwall, Brock, Brownville, Fairbury, Long Pine, New Helena, Talmage, Thedford, Wahoo, Weeping Water, West Point.

Fossil: Agate.

4. **Surirella striatula** Turp. in *Mem. du Mus. d'Hist. Nat., XVI. 1828.*

Pl. 21, fig. 793.

Broadly oval, sometimes spirally twisted, 95–160 μ long, about 75 μ wide; costae robust, about 1 in 10 μ, reaching to the median line; striations 14–15 in 10 μ; girdle face cuneate, showing marginal alae.

Devils Lake and fresh water near Devils Lake, N. Dak.

5. **Surirella robusta** Ehr. in *Ber. Berl. Akad., p. 215. 1840.*

Pl. 21, fig. 794.

Long-ovate, 135–365 μ long; pseudoraphe broad, alae distinct; costae very distinct, 1.5–2 in 10 μ, reaching nearly to the pseudoraphe, nearly perpendicular to the margins; striations indistinct, 10–14 in 10 μ. Var. *splendida* is a form somewhat smaller.

Common among luxuriantly growing algae in creeks, rivers, ponds, etc., also fossil: Alma, Anselmo, Burge, Cherry County, Crawford, Culbertson, Dismal River, Dunning, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Halsey, Lakeside, Long Pine, Norfolk, North Platte, Oakdale, Orleans, Red Cloud, St. Paul, Seneca, Snake River, Stanton, Stromsburg, Talmage, Tekamah, Thedford, Valentine, Weeping Water.

Fossil: Greeley County, Mullen, Spalding, Valentine.

Blackpipe, Little White River, Rapid City, Rosebud, S. Dak.; Blackhand, Ohio.

6. **Surirella elegans** Ehr. *Verb., p. 136, pl. III, 1, fig. 22. 1843.*

Pl. 23, fig. 860.

Oval, 180–240 μ long, 60–76 μ wide; costae delicate, 1.5–2 in

10 μ, extending nearly to the pseudoraphe; striations indistinct, about 22 in 10 μ.

In ditch, Thedford.

7. **Surirella ovalis** Breb. *Consid. 1838.* (According to *Kütz. Bacill., p. 61.*)

Pl. 21, figs. 795–806.

Ovate-elliptical or broadly ovate, sometimes subcordate, 27–80 μ long, 9–24 μ wide; costae short, marginal, perpendicular to the margin, 5–6 in 10 μ; striations very delicate, about 18 in 10 μ; pseudoraphe narrow. Very variable, most of the specimens found agreeing with the form called var. *ovata*. This form is often twisted like *S. spiralis*, as in figs. 799, 801. Var. *minuta* is a very small form, 12–25 μ long. Fig. 806 is a form found in Devils Lake, N. Dak.

Common among luxuriantly growing algae: Alma, Andrews, Anselmo, Arago, Ashland, Auburn, Benkleman, Blue Springs, Brock, Broken Bow, Brownlee, Central City, Clear Lake, Cook, Crawford, Culbertson, Dismal River, Emerald, Fairbury, Fremont, Gordon Creek, Grand Island, Hackberry Lake, Julian, Lakeside, Lincoln, Lodi, Louisville, Mason City, New Helena, Norfolk, North Platte, Omaha, Orleans, Ruby, Rupert, St. Paul, Salem, Seneca, Seward, Stanton, Stromsburg, Talmage, Tekamah, Thedford, Trenton, Valentine, Wahoo, Wann, Weeping Water, York.

Blackpipe, Rapid City, Rosebud, S. Dak.; Cheyenne, Wyo.; Chippewa Falls, Wis.; Ft. Collins, Colo.; Blackhand, New Concord, Rodney, Ohio.

8. **Surirella spiralis** Kütz. *Bacill., p. 60, pl. 3, fig. 64. 1844.*

Pl. 21, fig. 807.

Elliptical-lanceolate, 95–150 μ long, 40–50 μ wide, twisted around the longitudinal axis, resembling the figure "8"; costae 2–3 in 10 μ, extending nearly to the center.

In creeks, rivers, ponds, etc., also fossil: Anselmo, Callaway, Dismal River, Snake River, Valentine.

Fossil: Agate, Mullen.

Rosebud, Turtle River, S. Dak.

## 37. Campylodiscus

**Campylodiscus** Ehr. in *Ber. Berl. Akad., p. 11. 1840.*

*Calcodiscus* Rabenh.; *Coronia* Ehr.

Etym., from Gr. καμπύλος, curved, and δίσκος, disk, so named from the cells being nearly circular and curved.

Cells solitary, free, disk-shaped, disk twisted or saddle-shaped; valves round-elliptic with short, mostly radiate ribs and a marginal keel concealing the raphe; pseudoraphe median, but at right angles in the two valves. Chromatophores as in *Sphinctocystis*.

*A*. Central space with coarse dots.
  *b*. Valves bent. 1. *C. clypeus*.
  *bb*. Valves very much bent. 2. *C. hibernicus*.
*AA*. Dots lacking in the central space which is somewhat rectangular. 3. *C. bicostatus*.

1. **Campylodiscus clypeus** Ehr. *Abh., p. 201. 1840.*

Pl. 21, fig. 808.

Nearly circular, 85–200 $\mu$ in diameter, saddle-shaped; costae reaching about half way to the center, about 1.5 in 10 $\mu$; striations among the costae, 20–21 in 10 $\mu$, consisting of elongated dots; central portion of the valve filled with coarse dots irregularly or radially arranged.

Typically a marine species: Big Alkali Lake; pool by lake, Lakeside. Devils Lake, N. Dak.

2. **Campylodiscus hibernicus** Ehr. *Ber. Berl. Akad., p. 154. 1845.*

Pl. 21, fig. 809.

Nearly circular, 90–100 $\mu$ in diameter, very much bent; costae 1.5–2 in 10 $\mu$, very heavy near the margin, tapering toward the center, where they leave a nearly square punctate space.

In Rapid Creek at Rapid City, S. Dak.

3. **Campylodiscus bicostatus** W. Sm. *Brit. Diat., II, p. 88. 1856.*

Pl. 21, fig. 810.

Nearly circular, 30–50 $\mu$ in diameter, with narrow costae the spaces between which are punctate; central space somewhat rectangular with rounded angles, the center of which has no dots.

With *Cladophora* in creek: Cheyenne, Wyo.

GLOSSARY

**Ala.** Pl. *alae*. A wing. The same as carina or keel, in *Surirella*, etc.

**Auxospore.** The spore formed by the union of two cells, or the excessive growth of a single cell forming a new diatom larger than the parents.

**Carina.** Keel; the wing-like projection on a diatom valve.

**Connecting zone.** The portion of a diatom cell wall between the valves; the girdle.

**Convergent.** Pointing toward raphe at the ends, as the striations in some species of *Navicula*.

**Costa.** A rib; heavy markings on a diatom valve not consisting of rows of dots.

**Decussate.** From Lat. *decussatus*, crossed at acute angles like the letter X. Crossing one another in three directions as the striations in some species of *Gyrosigma*.

**Diatomin.** The coloring matter of diatoms. It is composed of phycoxanthin and chlorophyll.

**Dorsal.** The back, or outer side of a curved diatom.

**Endochrome.** The chromatophore of a diatom.

**Frustule.** An entire diatom cell including the valves, girdle, and contents.

**Fenestrated.** (Lat. *fenestra*, window.) With window-like openings.

**Girdle.** The portion of a diatom cell wall that connects the valves.

**Interzone.** A band between the portion of the girdles attached to each valve. In some genera there are no interzones; in others, one; and in others, two or more.

**Keel.** The same as *carina*. A wing-like projection on a diatom valve.

**Lumen.** A clear space at the margin and ends of a diatom cell caused by a thickening of the wall; seen in some species of *Stauroneis*.

**Naviculoid.** Shaped like a *Navicula;* boat-shape.

**Nodule.** A thickening in a diatom valve. In *Navicula*, for example, the nodules appear as dots in the center and at the ends.

**Perizonium.** The thin, unsilicified membrane of a young auxospore.

**Phycoxanthin.** The brown coloring matter of diatoms.

**Pseudoraphe.** A clear longitudinal space in a diatom valve; same as rachis.

**Pseudostauros.** False stauros. The appearance of a stauros in the center of a diatom valve caused by the striations being absent, and not by the widening of the central nodule.

**Punctate.** Consisting of rows of puncta or dots.

**Punctum.** Pl. *puncta.* A point or dot. The striations of most diatoms consist of rows of puncta.

**Rachis** or **rhachis.** A longitudinal line on a diatom valve in which there are no striations.

**Raphe.** A longitudinal slit in a diatom valve. It is the central line in *Navicula* and allied genera.

**Stauroneiform.** Having the form of a stauros or cross.

**Stauros.** The transversely elongated nodule as in *Stauroneis.*

**Sulcus.** Pl. *sulci.* A groove or depression in a valve.

**Valve.** One of the halves of the silicified cell wall of a diatom.

**Ventral.** The inner side of a curved diatom, opposed to dorsal.

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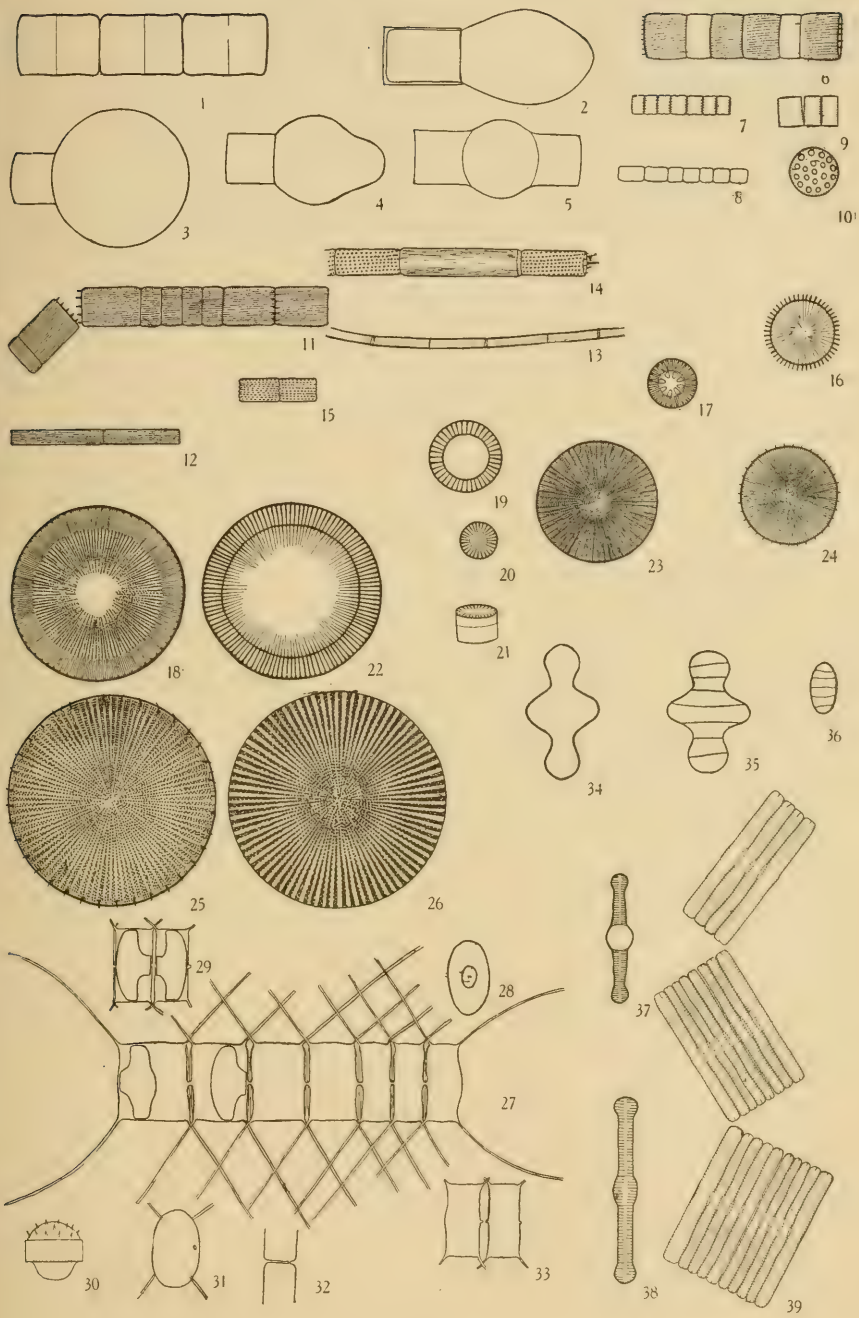
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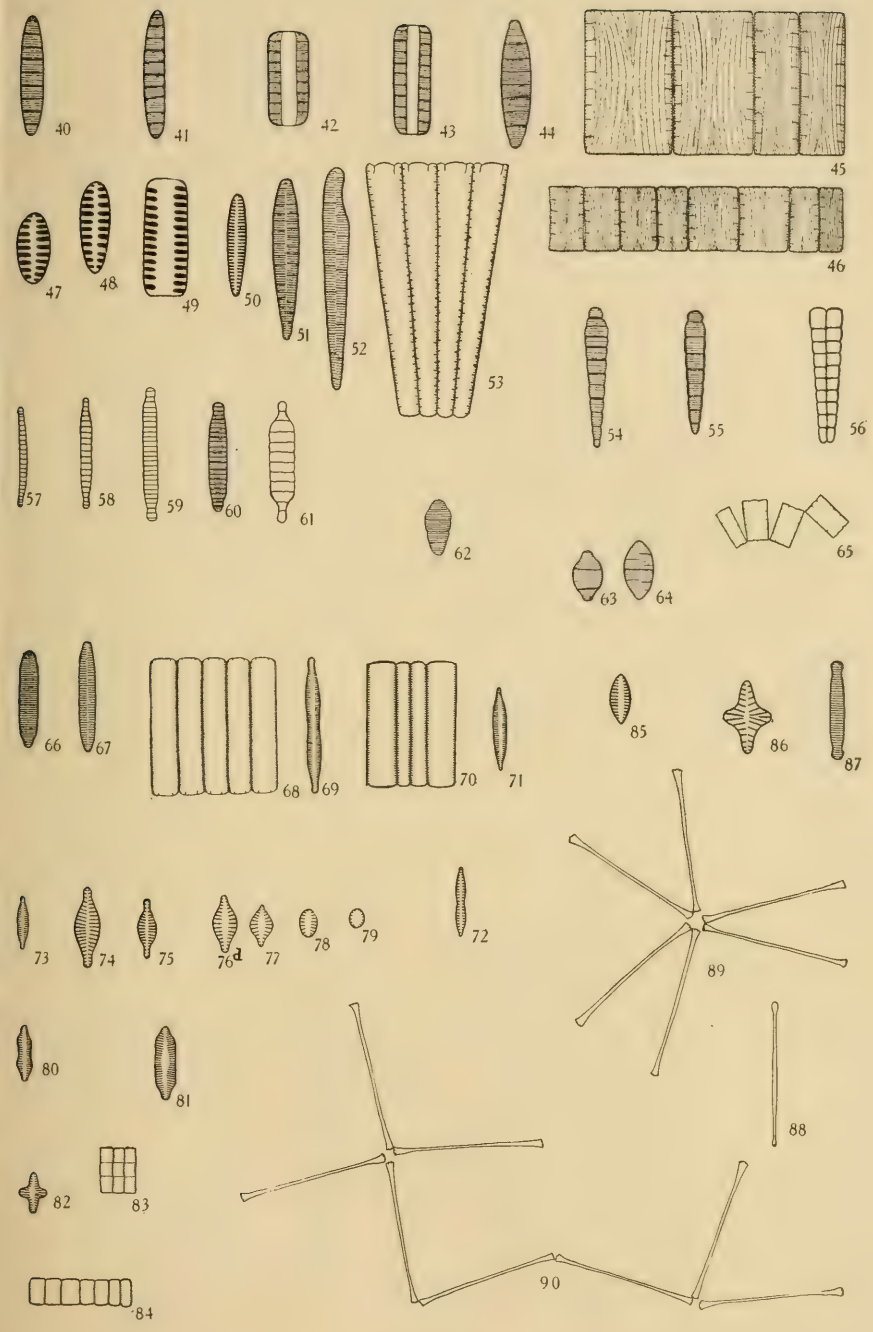
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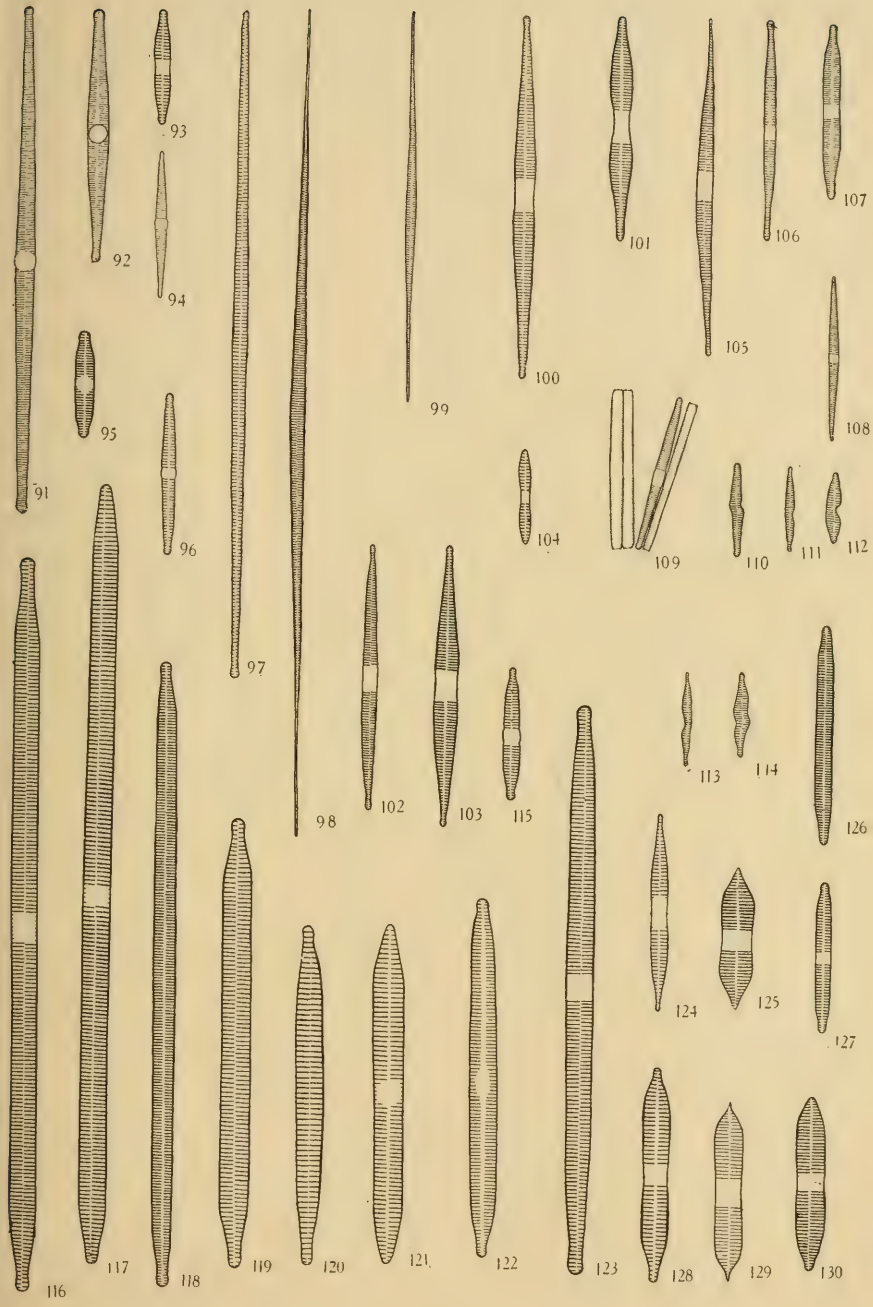
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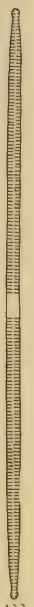
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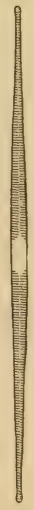
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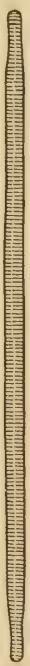
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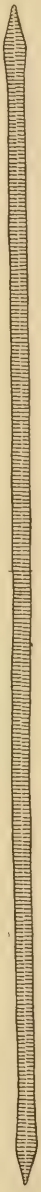
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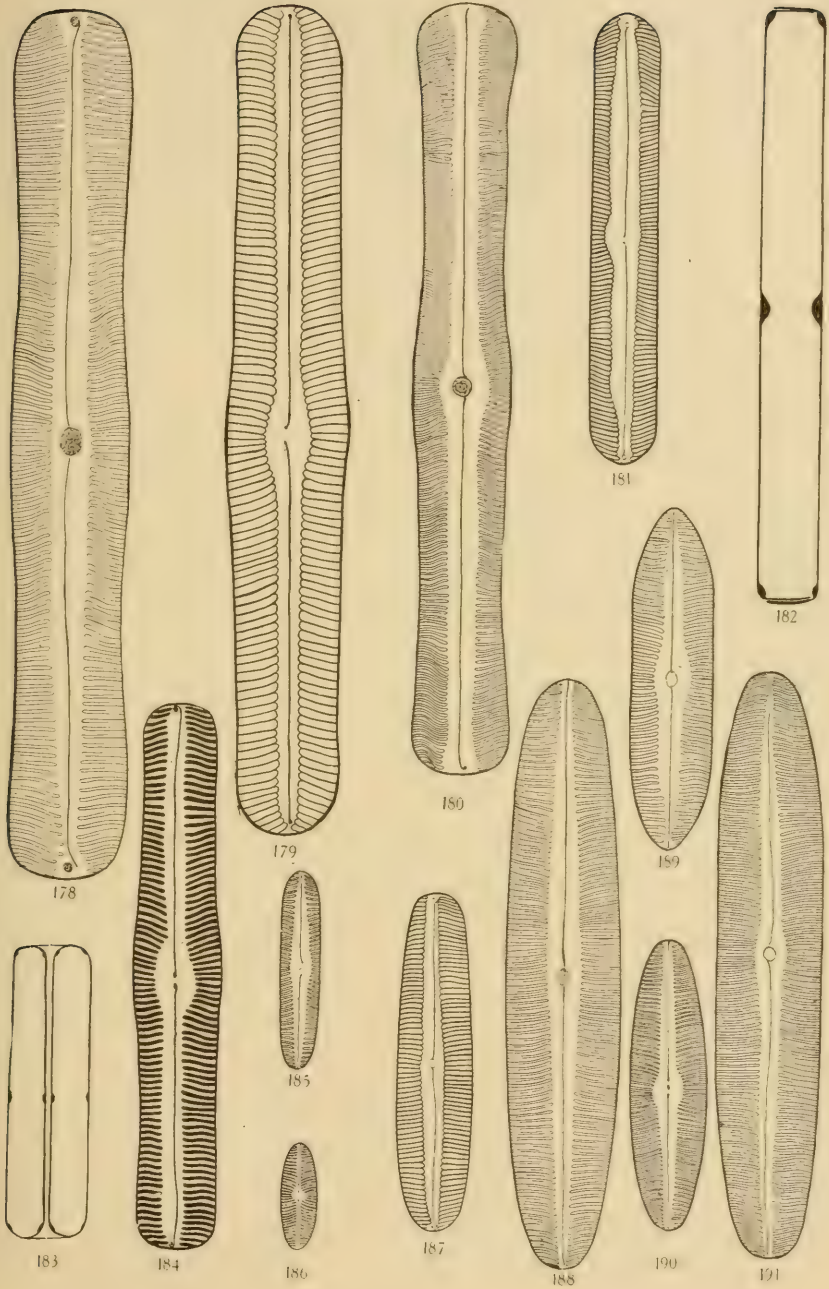

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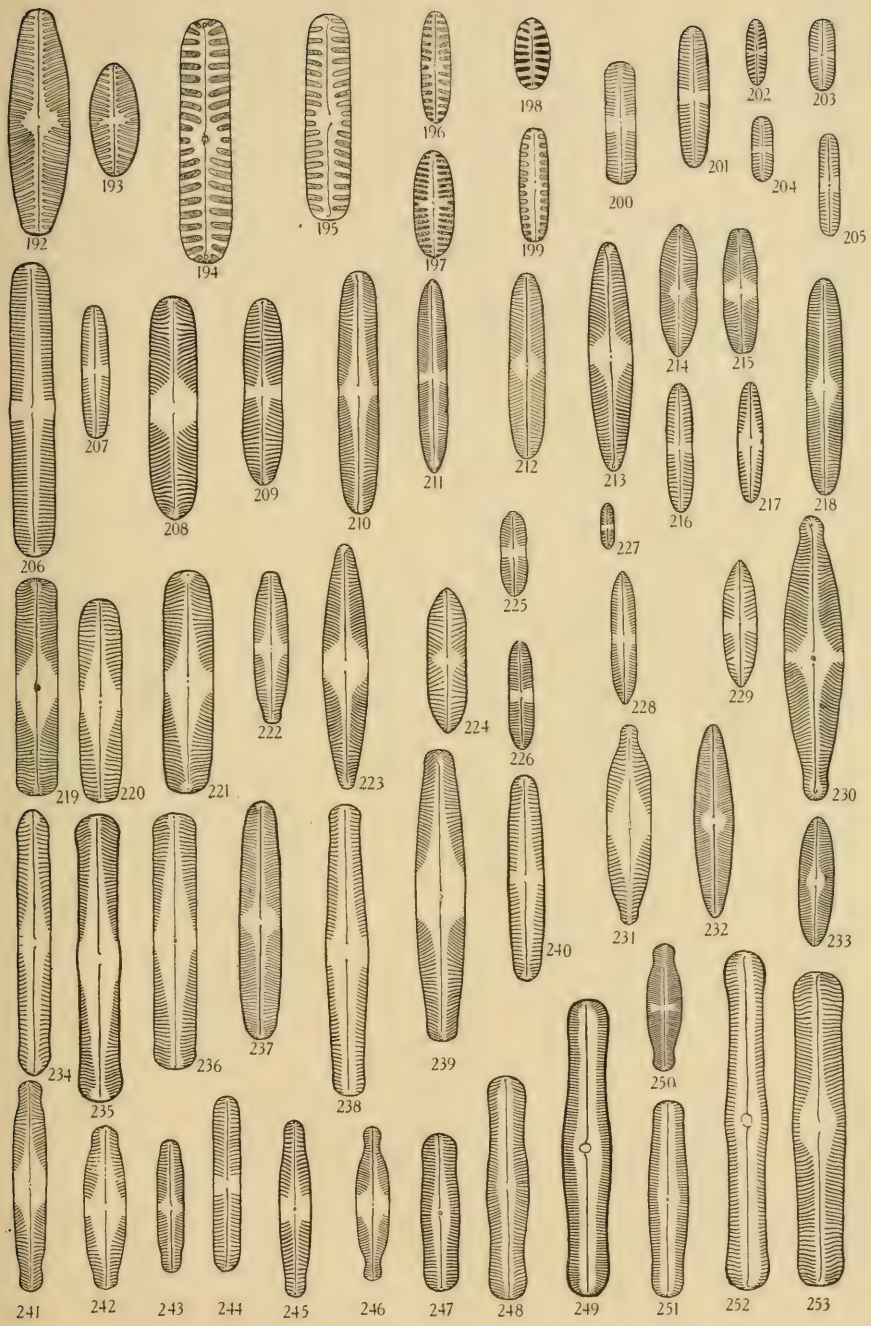
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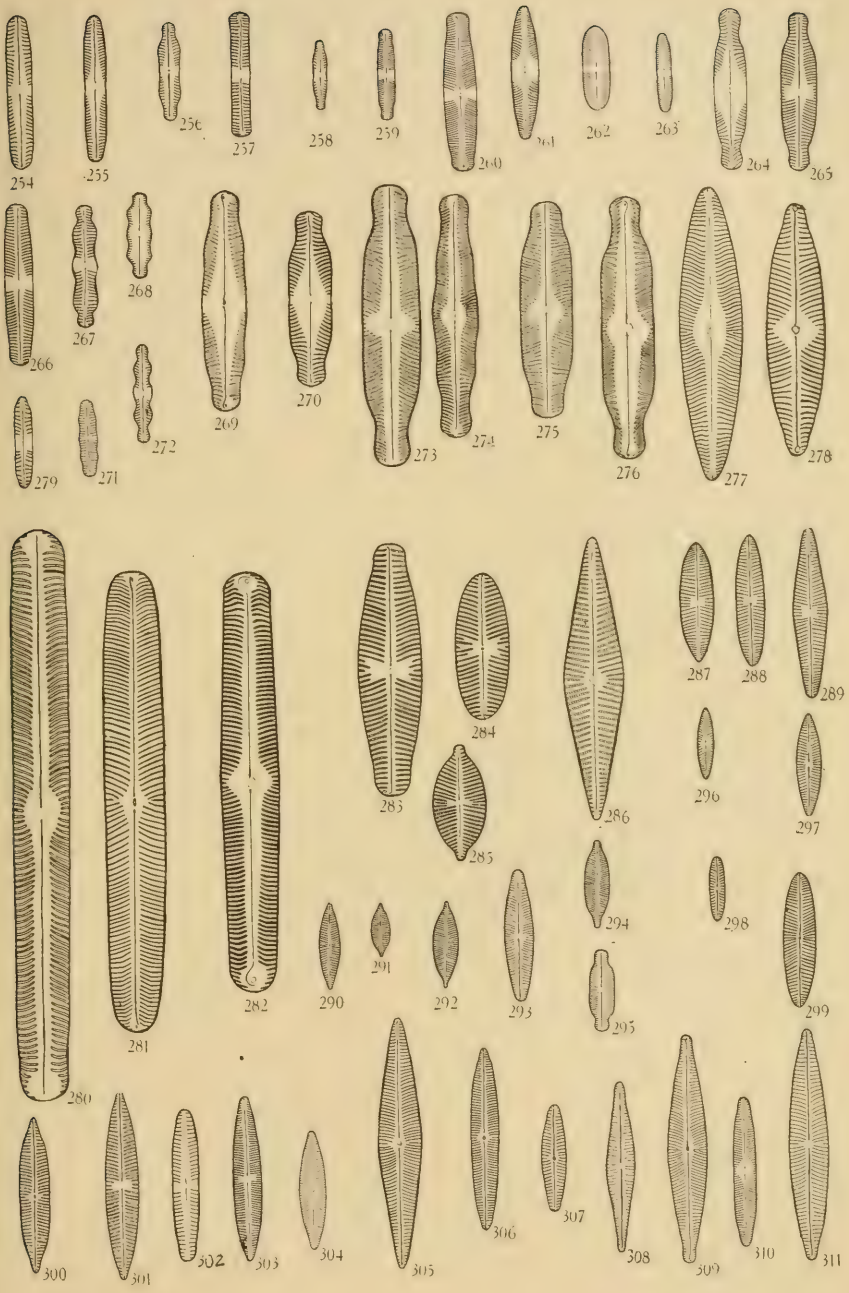
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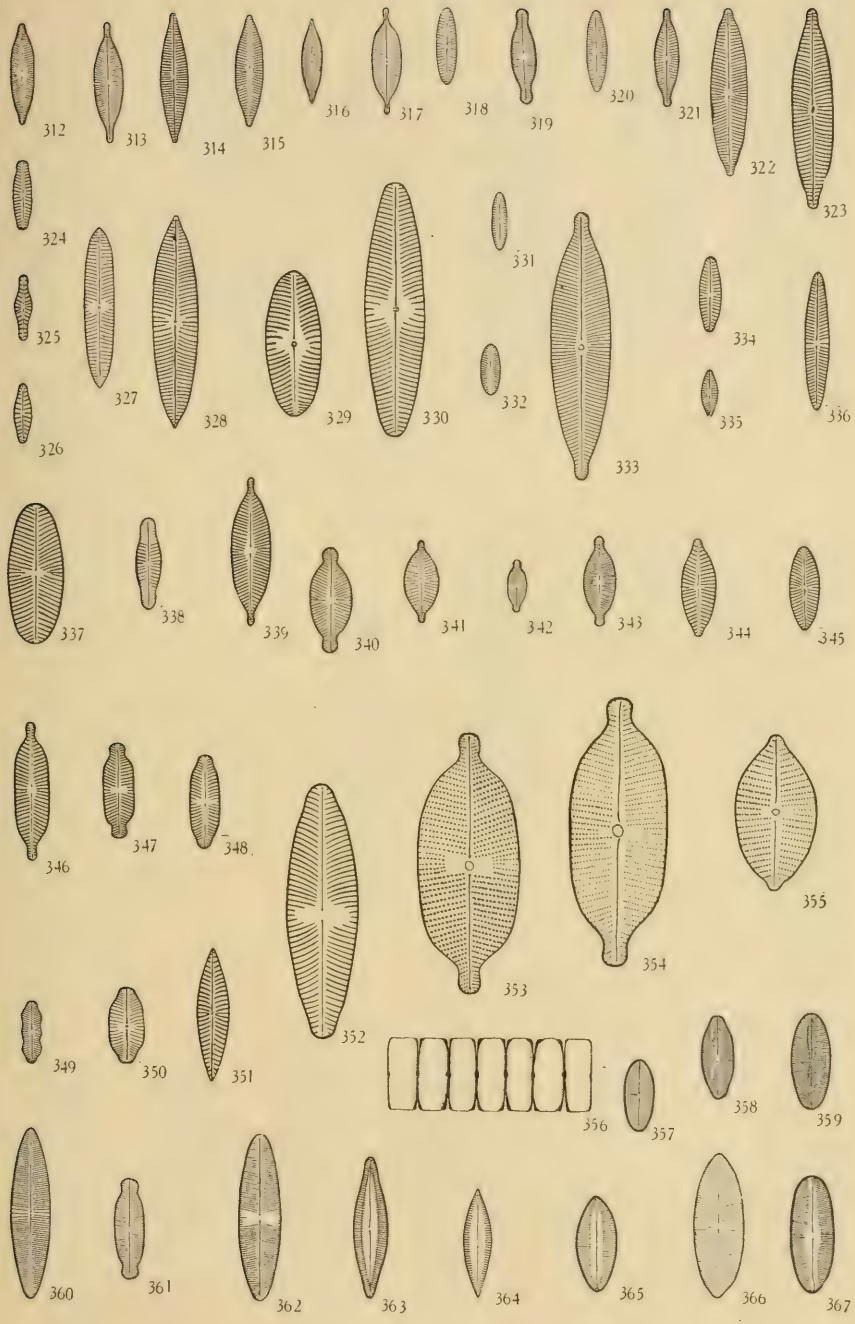
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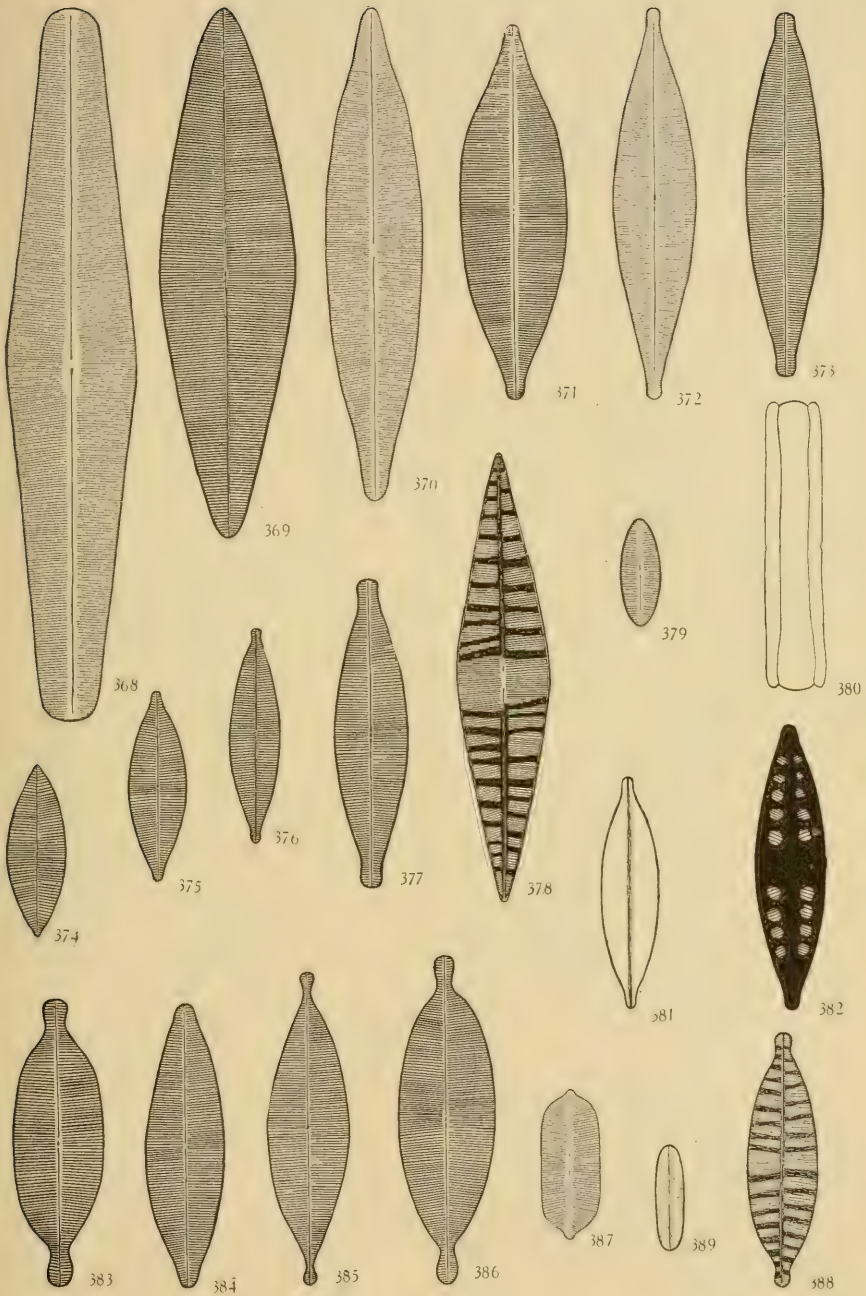
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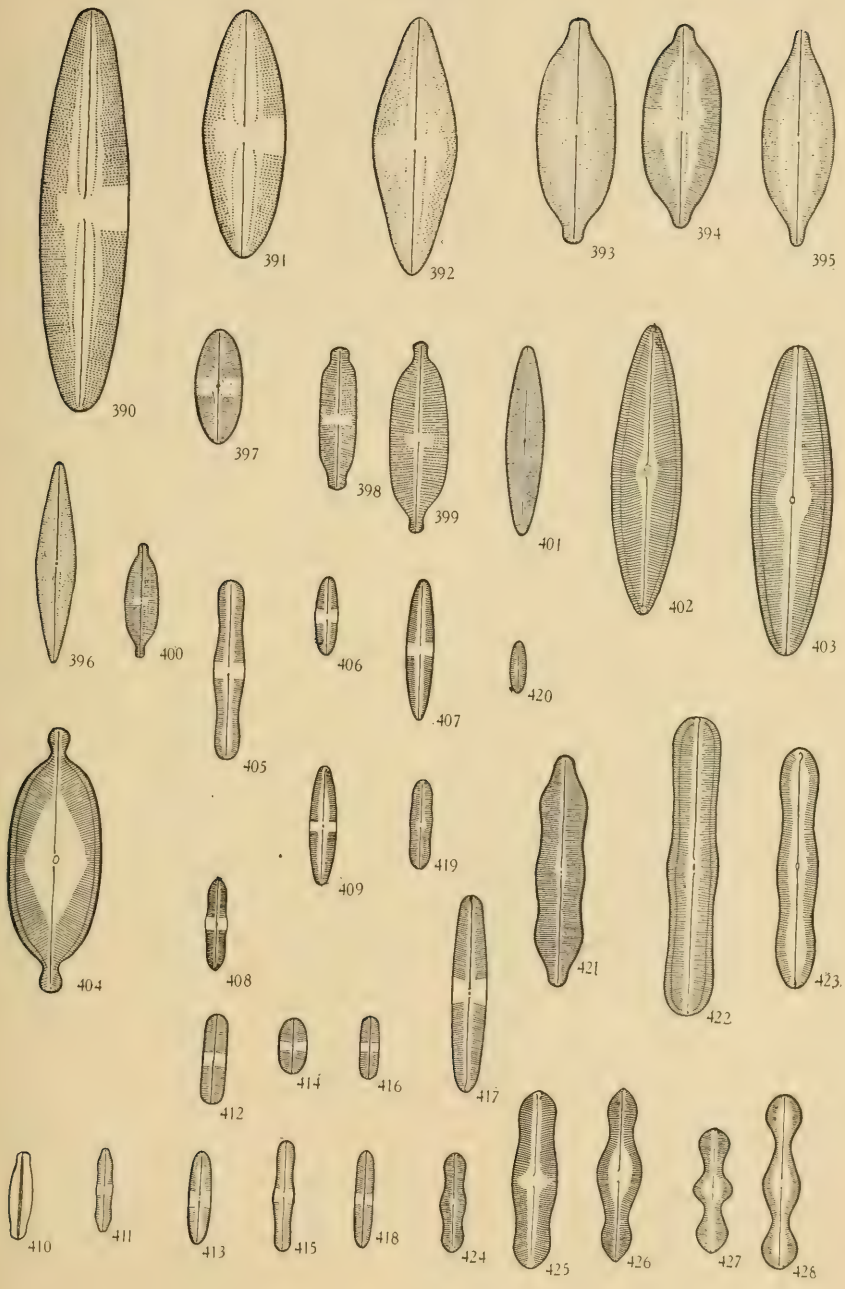
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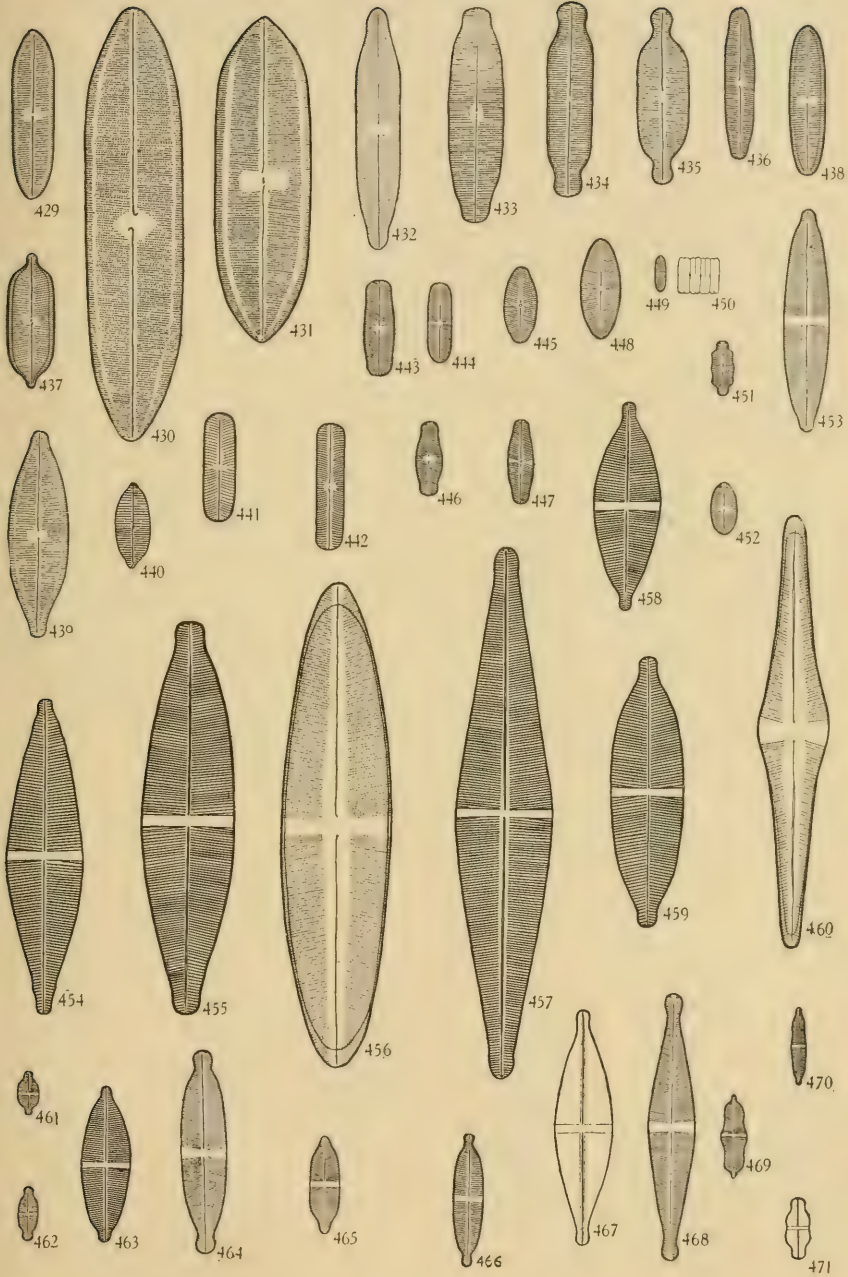
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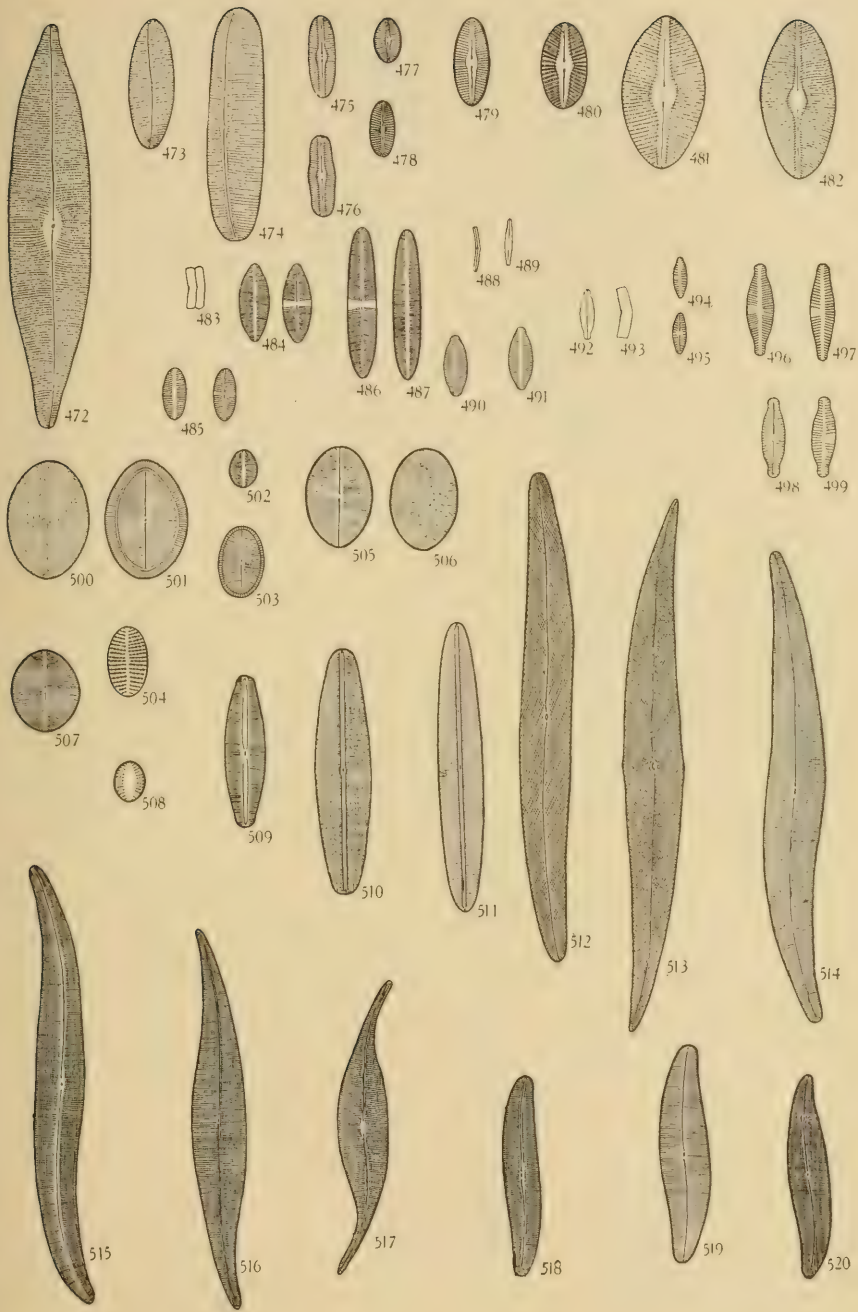
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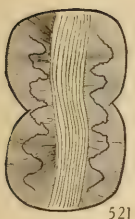
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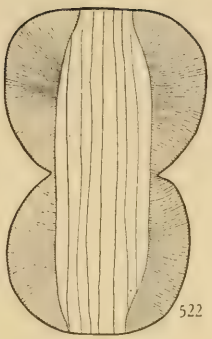
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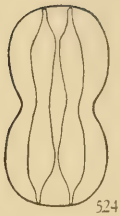
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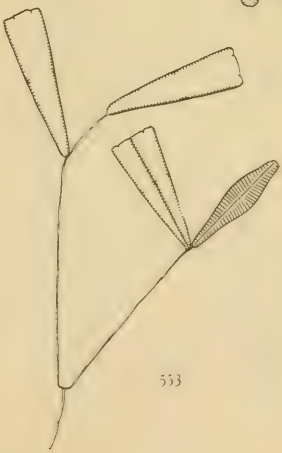
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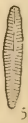
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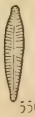
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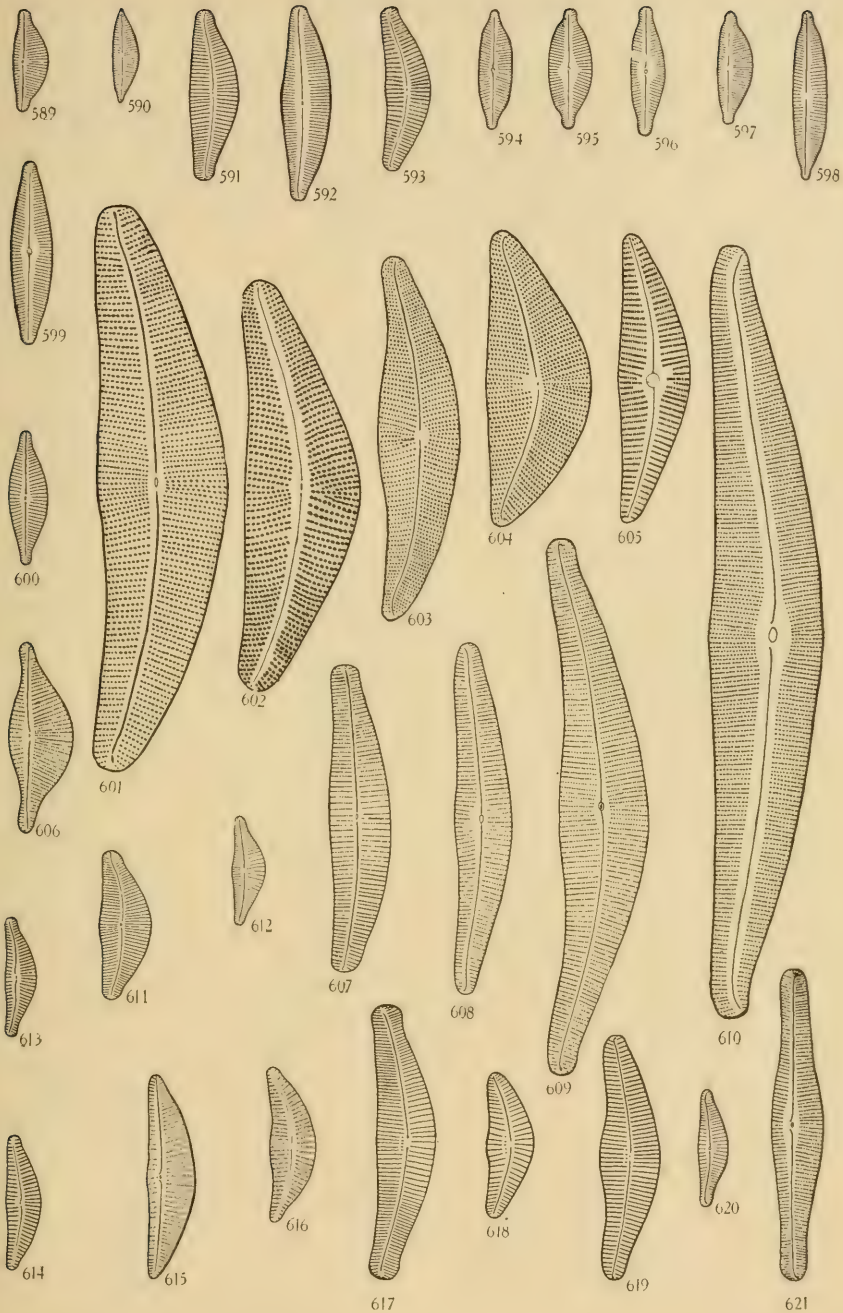
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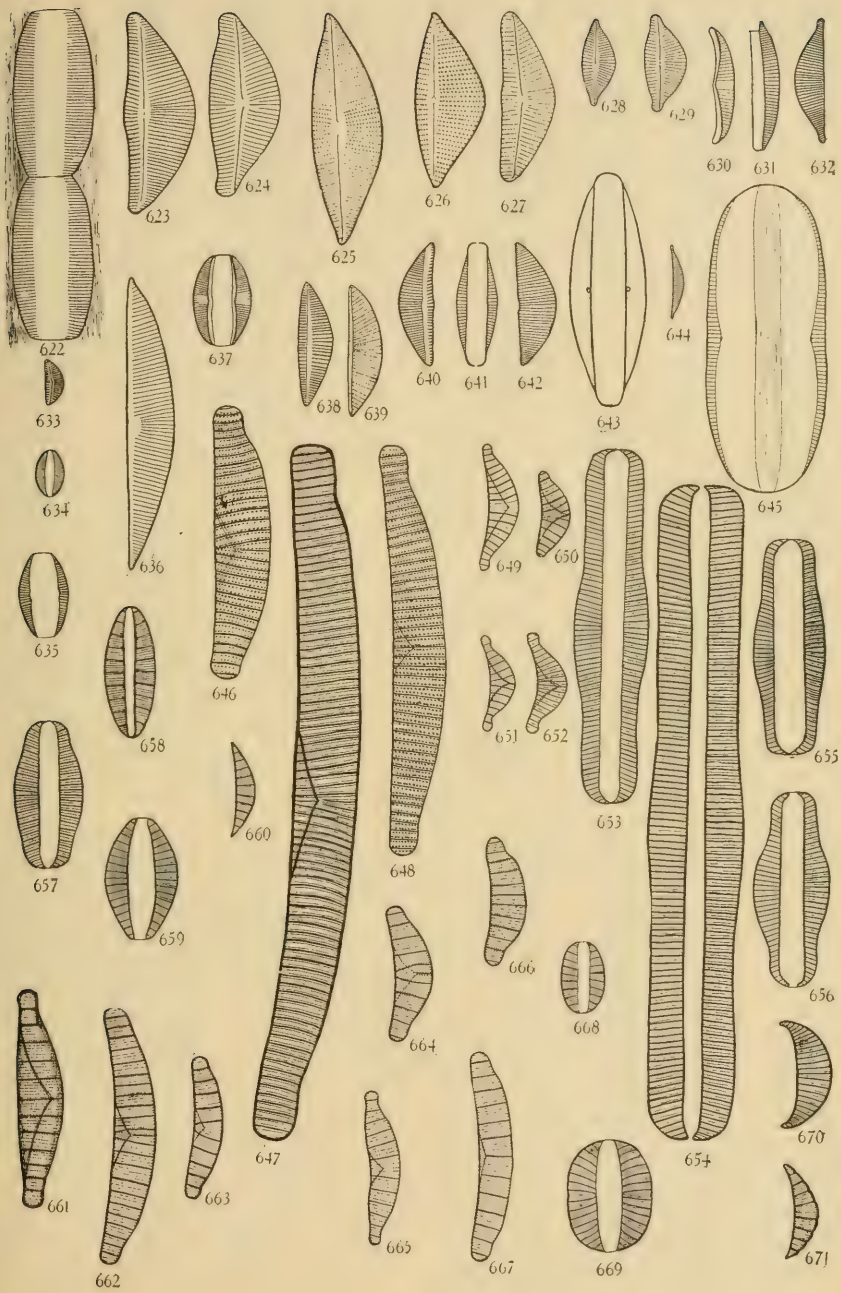
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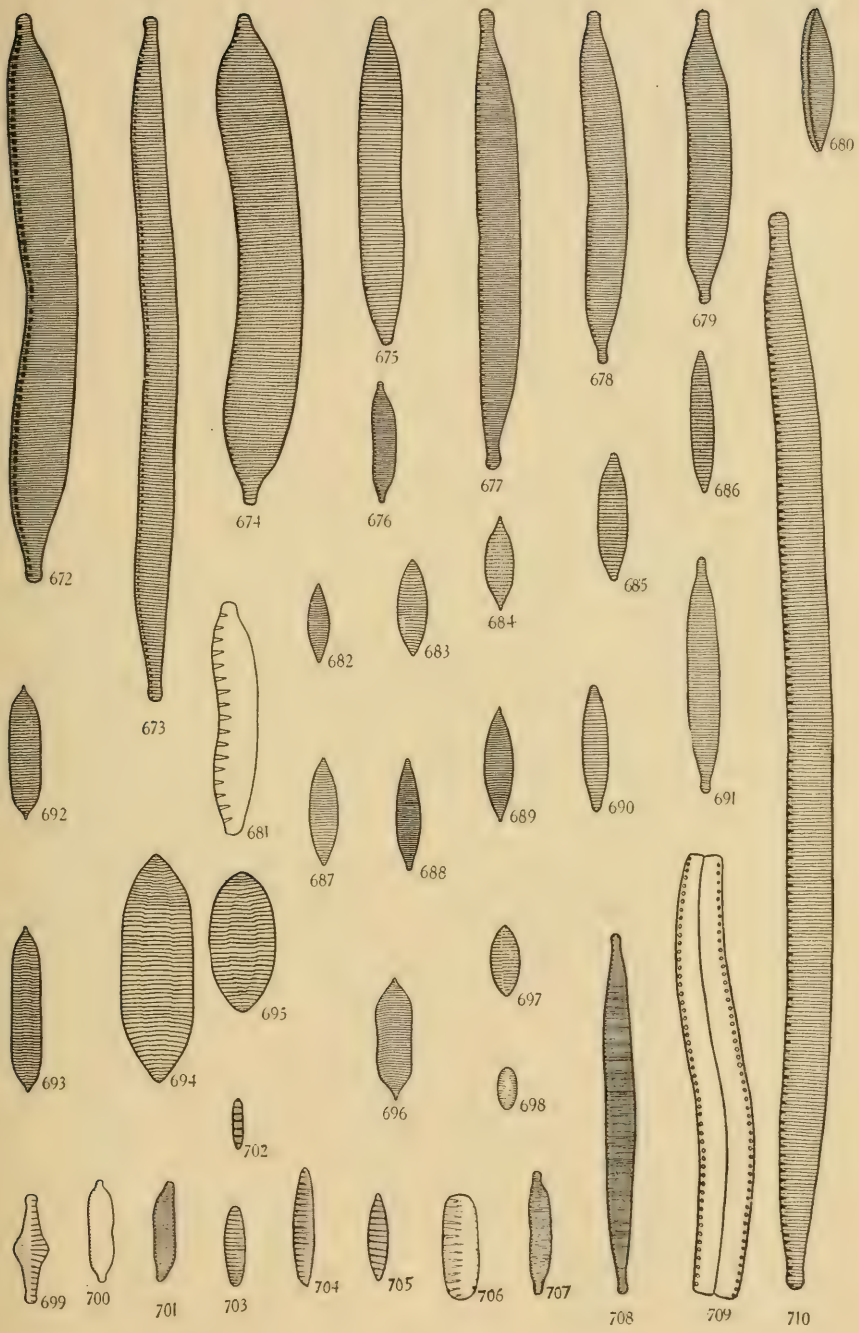
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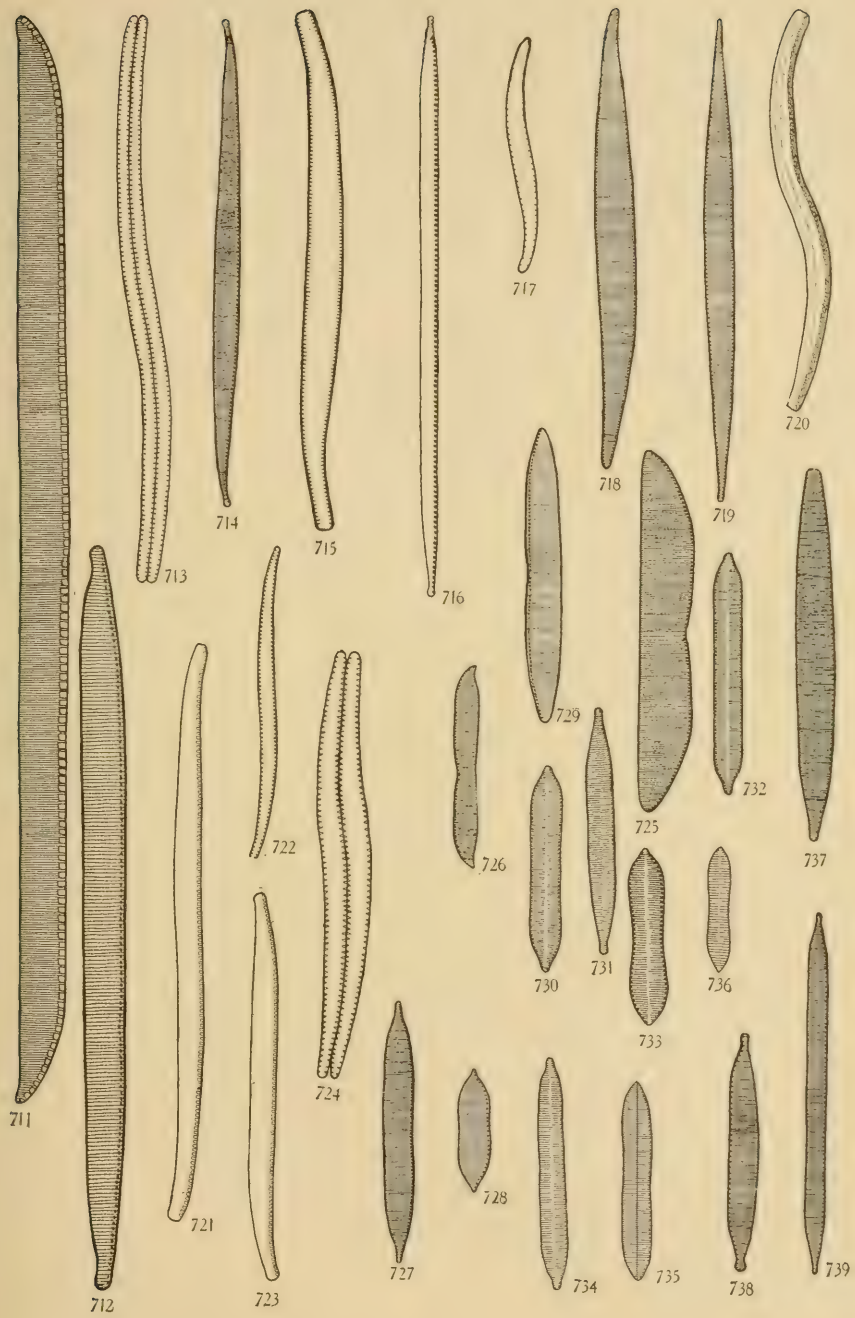
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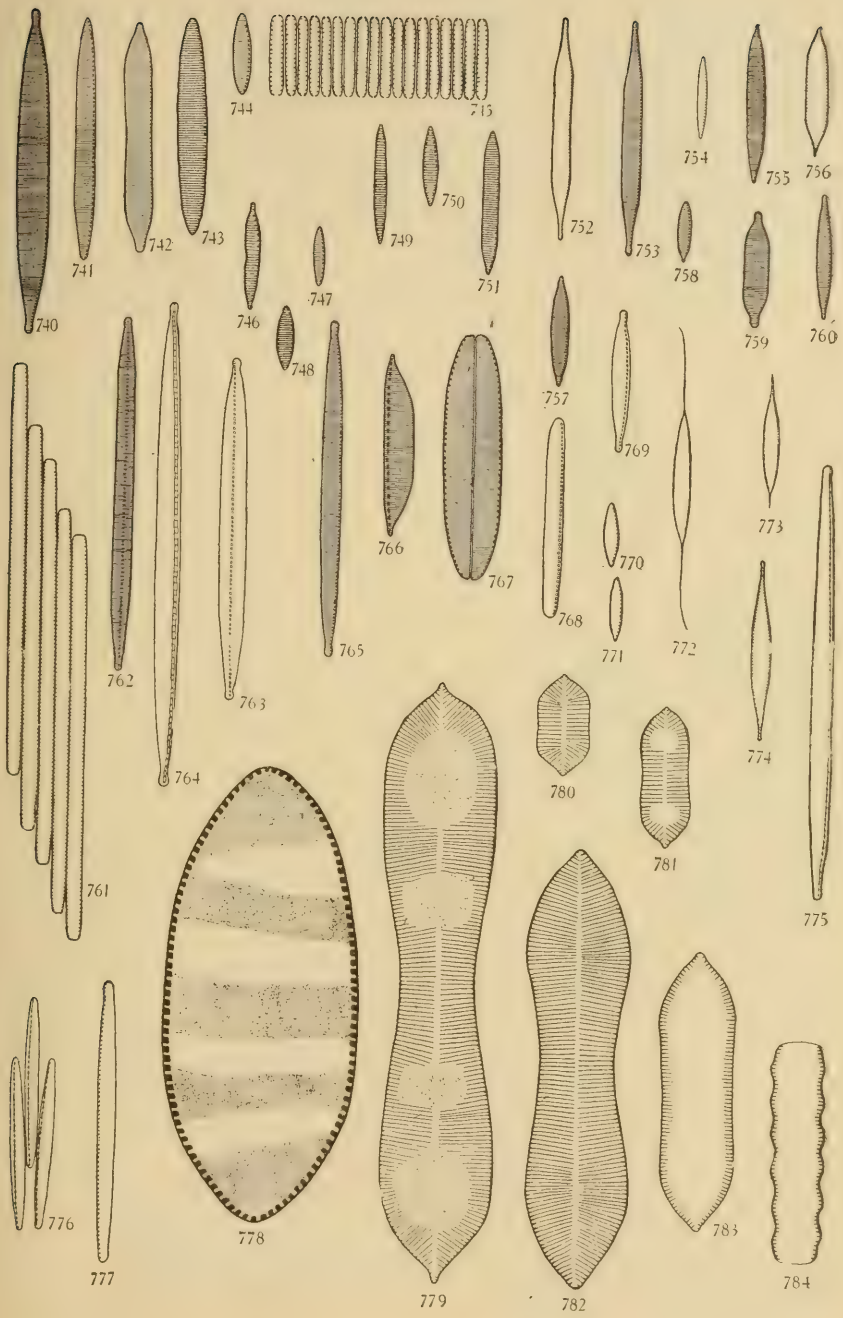
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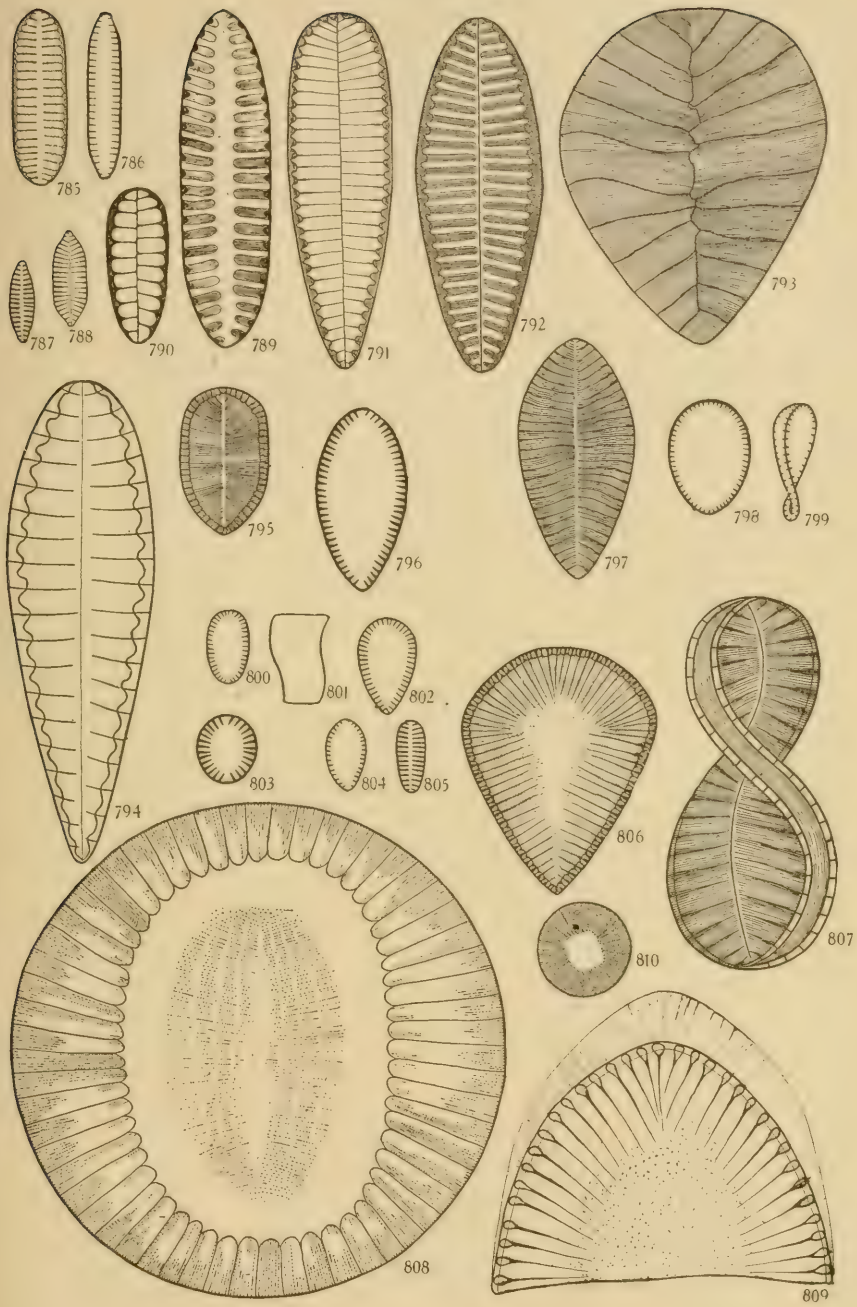
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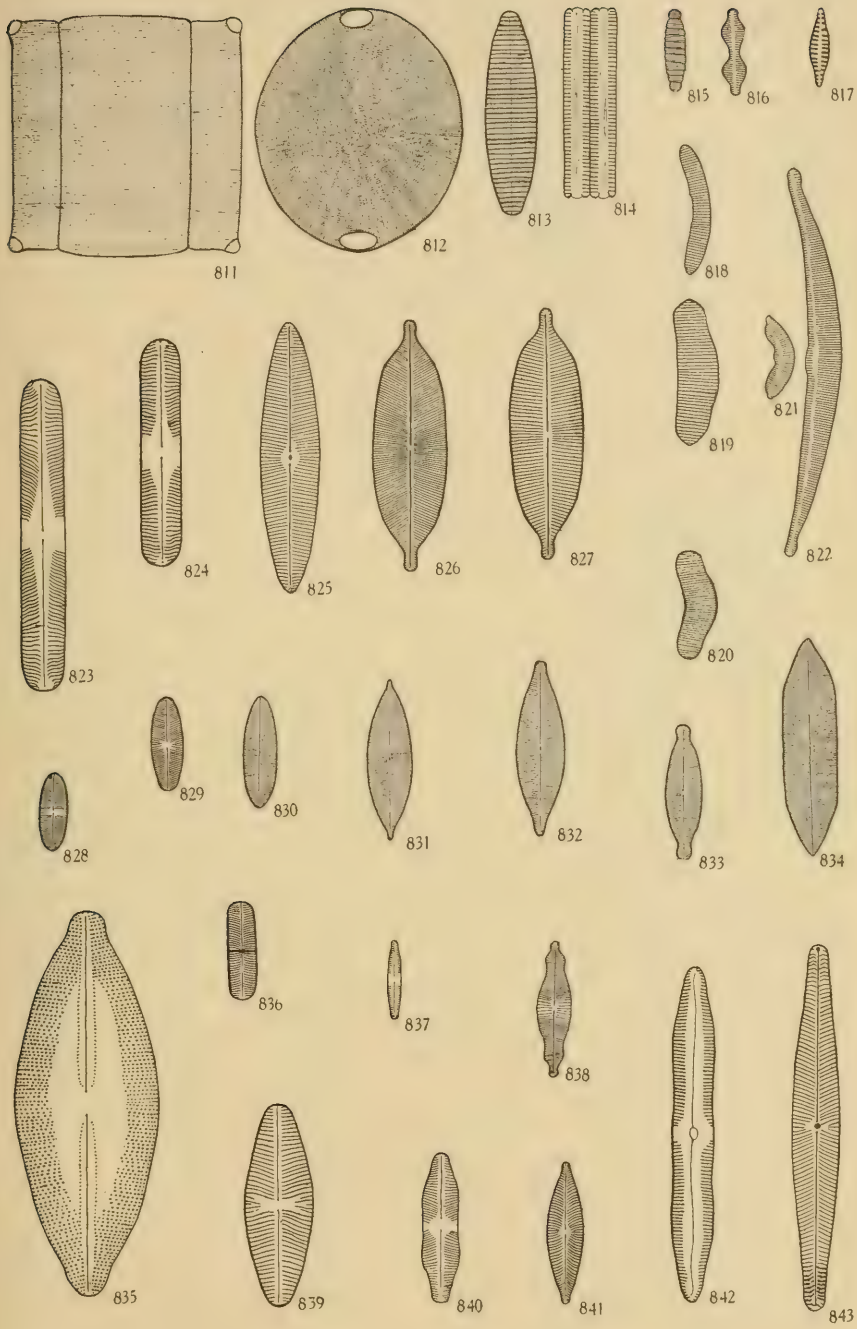
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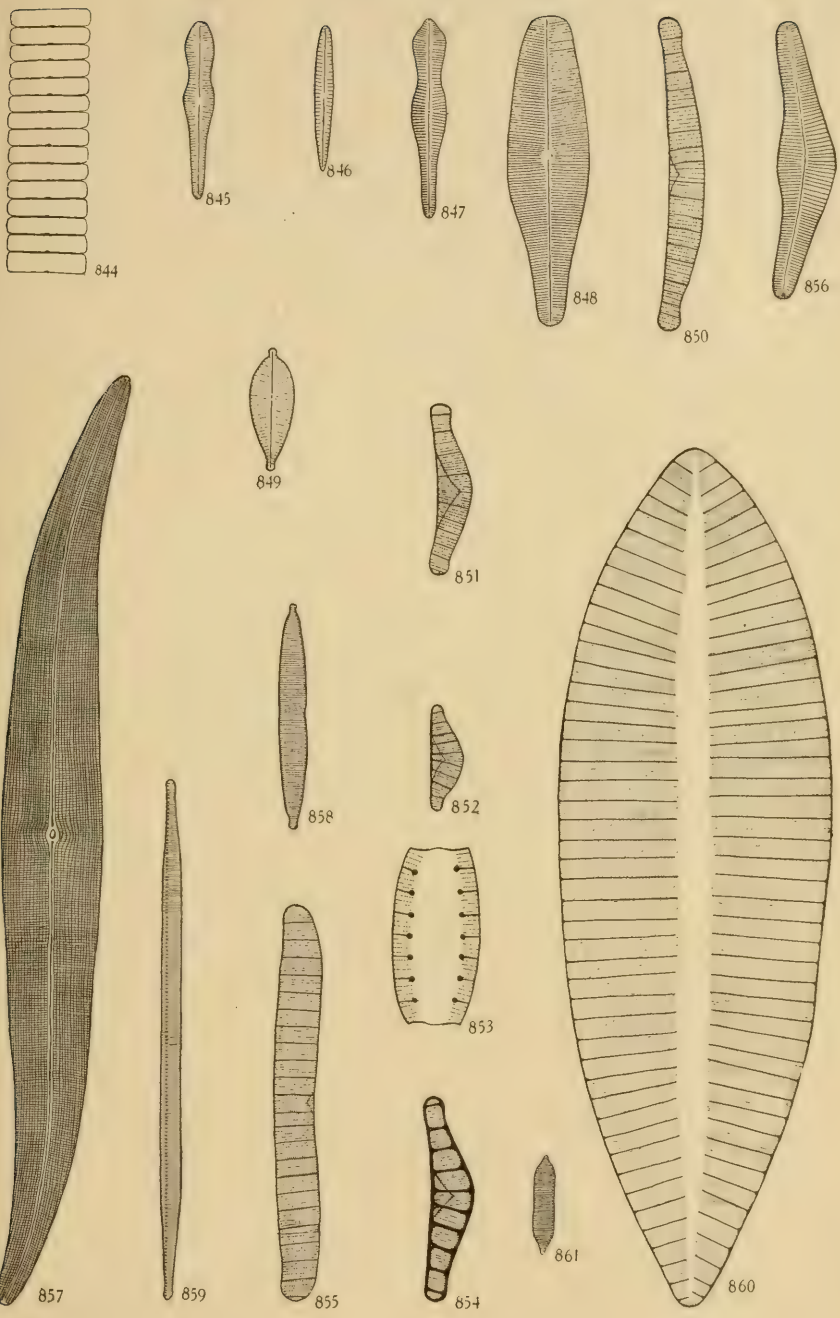
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LINCOLN, NEBRASKA

# UNIVERSITY STUDIES

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## CONGENITAL ANOMALIES OF THE ARTERIES AND VEINS OF THE HUMAN BODY WITH BIBLIOGRAPHY

BY C. W. M. POYNTER

SYNOPSIS

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### INTRODUCTION

As stated in my introductory study, 1916, the primary object of this work was to tabulate the vascular anomalies encountered in my dissecting rooms and to furnish references relating to such irregularities. I have found the literature so widely scattered and so difficult to get at that it has seemed worth while to classify it and arrange it in a usable form.

The material collected has grown to be so voluminous that it has been necessary to abridge as much as possible, consequently I have avoided any extended descriptions of my own cases, but have simply included them under their proper classification. The number of bodies on which my reports are based is 200 and those interested in statistical calculations may always use that number in

determining percentage frequency, except in those instances where I have specifically stated some other number. In presenting the bibliography the same usage has been employed as in the two preceding studies.

This study is intended to supplement the earlier studies, 1916 and 1919, and, together with them, to furnish a complete review of the vascular anomalies of the human body.

## HISTORICAL

In the long period after Galen, when almost no direct observations were made, there developed in the minds of anatomists a conception of the vascular system as a fixed and unvarying structure. Then, with the return to dissections, the wide variations from the accepted types attracted attention and were recorded as curiosities. A little later the growing need for exact knowledge by surgeons, in order to rapidly reach and ligate vessels, gave a new and added impetus to the study of the vascular tree with a resulting increase in the number of recorded variations. These records were soon followed by attempted explanations; Baer, Young, Serres, and others showed that certain variations corresponded to stages of development, while other investigators found similar patterns in the lower animals. It is difficult to present the general aspects of the subject for the last one hundred and fifty years in a chronological order. There is almost no subject in the anatomical field which has attracted so much interest; the bibliography includes the name of practically every anatomist of importance in the last four generations.

The problems arising from the study of vascular variations have furnished a stimulus for some of the best work in the fields of comparative anatomy and embryology in addition to improving the work of our dissecting-rooms and furnishing a better basis for descriptive angiology.

As soon as a similarity of vascular anomalies to lower form patterns was recognized a discussion began on "atavistic reminiscence" and many other of the complicated problems which the enunciation of the Biogenic Law brought in its wake. For those variations which could not be homologized with any of the patterns

found in lower phila Cunningham gave the name "anticipatory variations"; obviously with this explanation there can be no quarrel, for if any one doubts he need only wait and see. To sum up all of the comparative work it would seem that it has furnished incontrovertible evidence of the kinship of man to the lower animals and has been of the greatest value in establishing the morphological importance of various trunks and branches; but in the case of individual variations even the most enthusiastic comparative anatomist has not been satisfied with the simple fact of established resemblances. How they came to be so is not answered and, perhaps more important, it would seem that "Ontogeny may take an entirely new course, which in all probability has never appeared before and yet which immediately reaches an adaptive end result." Pearl (1908).

In conjunction with comparative work a large number of statistical studies have been published. They have yielded little in the way of explaining the factors of variation, but have furnished much exact information on their range.

It seemed for a long time that the whole question of variations was one for embryological investigation alone and many anomalies have been satisfactorily explained and many more only wait a fuller knowledge of the history of development; but, as this review will show, the embryologist is occasionally forced to create an "aberrant vessel" to satisfy an explanation, while the more fundamental problems, which are related to growth, are still unanswered.

In 1866 Baader, and later Aeby (1872), assumed that the primary vascular system was a general fine capillary net. Thoma (1893) presented the hypothesis that simple physical laws operating on the net determined the final adult pattern. Evans (1909) demonstrated that "Before there could be said to be limb arteries or veins a primitive plexus of capillaries grew into the limb tissue," and in the light of this, he observed, "If these processes are at work everywhere . . . the development of a given artery or vein to any portion of the body can not be due to miraculous predetermination, but to definite action of physical laws." If vascular variations are considered from this standpoint, they become only indicators of an early disturbance of definite physical laws and, conceivably, any possible variation can occur.

Lang (1856) became convinced from a study of the enervation of blood vessels that they must be as important morphologically as other structures of the body, while Marshall (1850), Hochstetter, and many others showed that the persistence of certain embryological stages might, through arrest of development, account for many of the familiar variations. The next significant work was that of Miller & McWhorter (1914), which demonstrated the formation of the embryological vessels in situ. It has been shown by Loeb, Stockard, Reagan, Webber, and others that the circulation of the blood is not necessary to the development of the vessels, and also that vascular irregularities are correlated with other structural irregularities in developmental disturbances.

In the regions where the stages of the development of the blood vessels have been worked out the data furnishes a satisfactory basis for the explanation of the adult variations usually encountered. It would seem, in the light of the more recent embryological investigations, that we are warranted in considering vascular anomalies as teratological problems. They are interesting as indicating developmental disturbances, kinship between man and the other animals, and wide adaptability within the organism. They are of slight practical value to the modern surgeon with his perfected technique and are by no means as limitless in number of patterns as the postulate of Baader would indicate.

## ARTERIES OF THE HEAD AND NECK

### ARTERIÆ

### *A. Carotis Communis*

In a former monograph on the aortic arches I have covered the various origins of this vessel ('16, p. 41). There is occasionally great variation of the caliber on the two sides and also at different levels of the individual trunk. Stahel (1886) found a constant contracture of the proximal portion and Biswanger (1879) found that adults acquired a dilation near the bifurcation which was carried on into the beginning of the internal carotid. The length of the vessel shows a wide variation, but measurements have not been made on a sufficiently large number of cases to be of any

comparative value. From my own measurements I am sure that such length differences will fall into a simple probability curve. Anatomists have generally used some arbitrary point as a vertebra or laryngeal cartilage to represent the point of division; Quain (1844) reported division at the cricoid cartilage 5 times in 295; I have recorded such division twice on the left and once on the right. Others reporting short trunks are Morgagni (1761), Burns (1809), Ryan (1812), Monro (1825), Otto (1830), Hart (1836), Hyrtl (1841), Dubrueil (1847), Nuhn (1849), Schwegel (1859), Potherat (1889), Kantor (1905), Orr (1906). A delay in division, making a long trunk, represents the other extreme; Quain found 10 in 295 in which the bifurcation was opposite the hyoid bone; I have found 18 such divisions and many others nearly as high; see also Demarquay (1845) and Reinhardt (1850), Boulard (1857).

### *A. Carotis Externa and Branches*

The external carotid may run lateral to the stylo-hyoid muscle, Quain (1844), Gruber (1876); I have twice encountered this variation.

The trunk may be lacking in that all of the branches spring from a common point, apparently the common carotid, Huber (1777), Burns (1809), Langenbeck (1822), Hyrtl (1841), Dubrueil (1847), Deaver (1888), Bellini (1894), Anderson (1889), Descomps (1910).

The general arrangement of its branches is much more constant than of the subclavian, but the variations have attracted much more attention, as indicated by the large number of anomalies reported. The number of branches varies; Livini (1903) thinks 9 the normal number, but this represents only an arbitrary number of individual rami and not a constant group, which occurs in only about 50 per cent. I am sure there is no advantage in attempting to average types of branching, for all variations tend to be individual.

### *A. Thyreoidea Superior*

I agree with Livini in finding it present in 100 per cent.; Labatt (1837) reported its absence. It is occasionally double, Tiedemann (1822), Lauth (1833), Quain 3:292, Gruber (1859), Anderson (1879), Bard (1875).

It may arise from the subclavian, Hyrtl (1860), Livini (1903); or from the common carotid, Quain 41:292, Dubrueil (1847) 4 cases, Barkow (1850), Parmentier (1850), Reinhardt (1850), Isaacs (1855) 2 cases, Bajardi (1874), Embleton (1872), Potherat (1889), Cavazza (1897), Livini 9 per cent., Poynter 7 per cent. It may arise by a common trunk with the lingual, Barclay (1812), Bajardi (1874), Livini 1.5 per cent. I have not observed this condition, but have seen a common trunk for the thyroid, lingual, and ext. maxillary quite similar to that of Thomson (1884); Livini considers this rare, not having encountered it in 400 observations. It has been reported as a branch of the external maxillary by Anderson (1879) and variations of its branches observed by Arnold (1838), Chassaignac (1840), Cruveilhier (1843), Gruber (1845), Dubrueil (1847), Hyrtl (1859), Walsham (1880).

*A. Pharyngea Ascendens*

Its origin shows wide variations; Livini finds it in conjunction with the occipital in 13 per cent., Quain 14 per cent., Poynter 15 per cent., and from the internal carotid in 6 per cent. I have not seen this latter condition. The ascending palatine is frequently spoken of as a branch of the ascending pharyngeal and I have found this arrangement in 10 per cent. In such cases the artery takes a course external to the constrictor muscle and a tonsillar branch from the external maxillary takes the course usually followed by this vessel. The ascending pharyngeal may be large and occupy a superficial position, Streets (1872), Farlow (1886), Sanderson (1887), Parker (1887), Foucher (1896), Griffin (1896), Paquin (1896), Demme (1902), Dienlafé (1906). Müller (1871) reports a branch to the hypophysis and Embleton (1872) a double artery.

*A. Lingualis*

It may originate from the common carotid, Barclay (1812), Bajardi (1874), Neuberger (1912); or from the external carotid with the superior thyroid, l. c.; or with the external maxillary, Haller (1747) 7:50, Quain 61:302, Livini 25 per cent., Dall'Acqua (1900) 20 per cent., Poynter 15 per cent.; or in common with the ascending pharyngeal, Livini .5 per cent.

An irregular course has been described by Hyrtl (1859), Pye-Smith (1871), Gruber (1872–8), Shepherd (1889), Morestin (1894), Funke (1897), Meriel (1903), Neuberger (1912). Some variation of the branches, Lauth (1833), Bajardi (1874), has been noted, but insufficient in extent to be profitable for analysis with the exception perhaps of the sublingual which has been studied by Bertelli (1903) in 50 cases and by Rouviere (1908); they conclude that it is normally a branch of the lingual, in 9:50 cases it arises from the external maxillary. Both Hyrtl (1873) and Rouviere decide that it is frequently lacking.

### *A. Maxillaris Externa*

It may be double, Bellini (1894). Krause (1868) says that it is frequently short, extending only to the angle of the mouth, but Dall'Acqua (1906) found this true in only 3 per cent. It may be represented only by the cervical portion and the face receive its blood supply from the transverse facial, Demarquay (1845), Arnold (1847), Dunn (1890). The origin and distribution of branches may be so irregular that they can not be interpreted from the description, Hame (1880); such variations are apparently individual and can only be classified on a comparative basis or must await a better understanding of the history of development. Another group of variations in which the internal and external maxillary are associated has been studied by Grönroos (1901), who reports a case and examines the literature. In his case the facial portion of the external maxillary is connected to the internal maxillary through a buccinator branch; other cases of such a loop are Joessel (1878), Kalantaroff (1887), Delitzin (1890), and earlier cases by Quain and Hyrtl (1859). Krause (1868) reports the ascending palatine from the occipital, Dall'Acqua (1906) from the external carotid 10 per cent., from the ascending pharyngeal 5 per cent., and Theile (1841) from the lingual. Rouviere (1908) presents a study of the sublingual terminations, while the tonsillar has been described by Haller, Luschka, Richter, and Dall'Acqua.

### *A. Occipitalis*

It may arise in common with the ascending pharyngeal, Quain 19:144, Pye-Smith (1871), Streets (1872), Macalister (1892),

Livini (1903) 16.3 per cent., or the posterior auricular, Livini 11.8 per cent. Horrocks, White, Lane (1884) report finding it as a branch of the internal carotid, as do Haller (1747), Tiedemann (1822), Hyrtl (1836), Quain, Beck (1846), Dubrueil (1847).

It may run superficial to the sterno-mastoid, Tiedemann (1822), Quain, Arnold (1847), Schwegel (1859). It may form a connection with the external carotid, Huber (1777), or with the vertebral, Green (1830), Schlemm (1830), Tiedemann (1846), or with its fellow within the skull, Gruber (1852), or with the middle meningeal, Jancke (1762), Soemmering (1800), Barkow (1851).

*A. Auricularis Posterior*

In its origin it may be associated with the occipital or with the ascending pharyngeal, Livini 1 per cent. The stylo mastoid may enter and cross the tympanum to enter the facial canal, Hyrtl (1836), or may go on to supply the dura. Arnold thinks this is only an abnormal course of a branch which normally comes from the ascending pharyngeal and is in relation to the tympanic nerve. This artery is homologized with a vessel in chiroptera and insectivora which springs from the common carotid and passes between the limbs of the stapes, Otto (1826), Meckel (1828), Hyrtl (1836).

*Rami Parotidi*

These to the number of two Livini found present in 95 per cent. of his series, and I have found them almost as constantly. Halbertsma (1863) saw them furnish a branch to the sterno mastoid.

*A. Sternocleidomastoidea*

It is a question whether the blood supply to the sterno mastoid should be attributed to an individual artery. Occipital, posterior auricular, parotid, and lingual all contribute normally to this supply, as Halbertsma has pointed out. Livini found a separate branch from the carotid in 42 per cent., while I found such a branch in 37 per cent.

*A. Masseterica*

This seems to be a much more constant branch than the last. It arises from the carotid just behind the angle of the mandible and

supplies the dorsal aspect of the masseter. I found it present in slightly more than 75 per cent., Livini 40 per cent., and Dall'Acqua (1906) in 75 per cent.

### *A. Maxillaris Interna*

The artery runs more frequently external to the external pterygoid, 54 per cent., Thompson (1898), Long (1890). It may be crossed by the inferior alveolar nerve, 3 times, or the maxillary vein, Guy's Hosp. Repts. (1873). The superficial temporal may arise from it, Haller (1747), or a connection may be made between it and the superficial temporal, Joessel (1878), Turner (1878), Kalantaroff (1887), Delitzin (1890), Groenroos (1901). It may arise from the external maxillary, Quain, Hyrtl (1859), Delitzin (1890).

The deep temporal, masseter, and buccinator vary in origin, relations, and anastomoses, Gruber (1852), Krause (1868), Grönroos (1901). The infra-orbital may terminate in the canal, penetrate the orbit and anastomose with the ophthalmic, furnish the superior labial, Lauth (1833), Schlemm (1830), or furnish the angular, Gruber (1849*b*), Dall'Acqua (1906), Poynter 3 times.

A relation between the middle meningeal and the ophthalmic is shown by the anomalies. The middle meningeal may furnish an accessory branch to the ophthalmic, Blandin (1834); supply the entire trunk, Krause (1841), Tiedemann (1846), Dubrueil (1847), Curnow (1873), Musgrove (1892); or supply the lachrymal branch, Haller (1753), Bell (1797), Murray (1798), Barkow (1866), Curnow (1873), Walsham (1880). Curnow also reports a case in which the ophthalmic supplied the middle meningeal. Anderson (1880) describes a large palatine branch springing from the middle meningeal, and other variations are reported by Rocher (1899), Meyer (1913), Malagazzi (1914). Alexander (1899) and Bien (1907) report persistence of the stapedial artery.

### *A. Temporalis Superficialis*

It shows great variation in its distribution; Grote (1901) has made a statistical study of its distribution. An early division of the artery has been reported by Bardeleben (1894). Parietal

trunk may be lacking and be supplied by the posterior auricular 20 per cent., terminal branches may be double, 8 per cent.

### *A. Carotis Interna*

The internal carotid is occasionally somewhat irregular in its course, Hyrtl (1841), Tigri (1866), Thompson (1898), Moorhead (1902), Hansen (1903), Sack (1907); or tortuous, Stimson (1885), Hulke (1893), Skillern (1912); or the caliber varies on the two sides, Hyrtl (1836), Orr (1906). One vessel may be lacking, Tode (1787), Quain (1844), Wyeth (1878), Flemming (1894), Fisher (1913), Timbrell (1913), Lowrey (1916).

The third portion of the artery is more subject to variations than the other portions. In the cavernous sinus a branch may arise and pass backward to join the basilar, Quain, Tüngel (1860), Duret (1873), Tigri (1866), Müller (1871), Tarenieckí (1880), Hochstetter (1885), Windle (1887), Smith (1909). The latter thinks that the condition is due to the persistence of an aberrant vessel developing early when the two are in close proximity.

### *A. Ophthalmica*

The ophthalmic artery is the first branch to develop from the internal carotid and appears about the 7-mm. stage. The hyaloid develops from this at a somewhat later period, Dedekind (1909). The ophthalmic may be unassociated with the internal carotid, but may come from the middle meningeal, l. c., or it may consist of a trunk to the retina only and the other orbital vessels be derived from neighboring arteries, Carnow (1874), or it may be double, Barkow (1866).

The lachrymal may be wanting or supplied by some other vessel, most frequently the supra-orbital is the continuation of the lachrymal. Cruveilhier considers that the nasalis is normally a branch of the angular; Dall'Acqua (1906) finds this true in only 5 per cent.

The hyaloid artery appears in the 22-mm. stage as a branch from the nasal side of the common ciliary; Versari (1903) and Fuchs (1890) say it atrophies soon after birth. Müller (1856) reported finding the artery frequently in the ox and predicted that such a condition would be discovered in the human eye. The prediction

was confirmed with the microscope by Meissner (1857) and Wallman (1858), and with the ophthalmoscope by Zehender (1857). Few of the cases reported as persistent consist of functioning vessels, but of cords and small threads attached to the retina or lens. DeBeck has pointed out that this condition must not be confused with an anomalous course of the centralis retinæ, which the cases of Leibreich (1871), Little (1875), Schapringer (1873), Czermak (1882), Cullan (1875), Reiban (1876), Fournot (1880), Hershberg (1881), Hunek (1885), Frost (1887), and Bondi (1899) undoubtedly are. It is difficult to estimate the percentage of persistence of the artery or its remnants, but Cullan (1875) found 3 cases in somewhat less than 500 colored children examined. The following reports have been collected:

Müller (1856), Messiner (1857), Saemisch (1863), Zehender (1863), Wecker (1865), Laurence (1866), Becker (1868), Mauthuer (1868), Stilling (1868), Cowell (1869), Manz (1870), Berthold (1871), Liebreich (1871), v. Oettengen (1871), Kipp (1873), Nettleship (1873), Schapringer (1874), Rieban (1874), Webster (1874), Cullan (1875), Brailey (1876), Noyes (1876), Schmidt (1877), Haab (1878), Badal (1880), McHardy (1880), Bayer (1881), Carreras (1881), Gardiner (1881), Holmes (1881), Little (1881), Rumszewicz (1881), Berger (1882), Everbusch (1882), Fuchs (1882), Galezowski (1882), Seely (1882), Streatfield (1882), Ulrich (1882), Snell (1883), Dimmer (1884), Lang (1885), Remak (1885), Carter (1886), Derbierre (1886), Haenel (1886), Picque (1886), Reuss (1886), Hess (1888), Magnus (1887), DeSchweinitz (1888), Despagnet (1888), Felser (1888), Meyer (1888), Randall (1888), Sulzer (1888), Tangeman (1888), Hasbrouck (1889), Pangeman (1889), DeBeck (1890), Fuchs (1890), Risley (1890), Beloff (1891), Price (1891), Williams (1891), Pulvermacher (1892), Mitvalsky (1893), Carson (1895), Lopez (1895), Deyl (1896), Günsburg (1899), White (1896), Giles (1897), Terrien (1897), Claibonne (1898), Marlow (1898), Zentmayer (1898), Hirsch (1899), Silcock (1899), Zentmayer (1899), v. Duyse (1902), Flemming (1902), Peserico (1902), Alexander (1903), Eason (1903), Jerussalemski (1904), Shoemaker (1906), DeVriese (1908), Renault (1909), Green (1912), Bowes (1913), Killick (1913), Nelson (1914).

### *Circulus Arteriosus (Willisi)*

Since so many of the variations of the terminal rami of the internal carotid are reported under the circle of Willis, it is easier to consider all of these variations under this head. DeVriese (1904)

has studied the arteries of the base of the brain both in the embryo and adult and comes to the conclusion that the posterior cerebral arteries are branches of the internal carotid, and that in a post-embryonal period an anastomotic connection is established with the basilar which later enlarges as the proximal portion of the cerebral trunk contracts into a posterior communicating. In 1905 she showed that the anterior cerebrals are primarily parallel vessels without connections, later they form a system or plexus of connections out of which the adult condition is developed. Vastorini-Cresi (1905) thought that there was a fusion between the two embryonal vessels. My own investigations convince me that DeVriese has correctly interpreted the formation of these vessels. In many cases the plexiform condition persists throughout life.

From a study of the basilar in the dog DeVriese concluded that it is primarily double and represents the primary caudal terminal branches of the internal carotid which later fuse, after establishing communications with the vertebrales. Cases in which there are two basilars, each communicating with the carotid of its side, can be explained by this order of development. Cases are reported by Decker (1886), Macalister (1888), Cavalari (1906); partial fusion by Serres (1830), Otto (1838), Davey (1839) 2 per cent., Malgaigne (1842), Quain (1844), Barkow (1869), Randall (1888), Cavatorti (1907), Blackburn (1907).

The connection between the carotid and basilar may drop out, leaving the circle incomplete, Barclay (1812), Davey (1839), Hyrtl (1842), Quain (1844), Barkow (1869), Müller (1871), Webber (1882), Hochstetter (1885), Incoronato (1872), Flemming (1894), Berry & Anderson (1909), Poynter.

The posterior cerebrales may be unequal or double, Barkow (1869), Gordon-Shaw (1909).

As already pointed out at one stage of the development, the anterior cerebrales present a plexiform condition, and, as in other parts of the body, this is fruitful of many variations. In the brains I have examined there has been the widest range of pattern from two well-developed and separate arteries to a complex plexus throughout the entire region. Various authors have commented on anomalies, but the range of "normal" seems so wide that it is hardly worth while to review the literature.

Many of the studies of the circulation of the brain have been made on defectives and insane and all of these investigators have seemed to hold the idea that some subtile connection exists between arterial anomalies and defective brain function. The quoted percentages of variations can hardly be taken at face value because the standard for computation is more nearly some ideal text figure than the condition found in 100 supposedly normal individuals. Barbieri (1868) found 15 per cent. anomalies in 1,145 brains of idiots. Fregerio found 21 vascular anomalies in 37 insane, and Blackburn (1907) 155 of 250 insane with such anomalies, while Longo (1905) found 29 anomalies in 50 supposedly normal brains. A very excellent piece of work was done by Mori (1893), who found 32 examples of vascular anomalies in 350 insane; this agrees with Windle (1887), who studied 200 cadavers and found that wide latitude should be employed in determining the normal. More recently Fawcett and Blackford (1905) examined 700 specimens.

### *A. Subclavia and Its Branches*

I have previously, '16, p. 41, discussed the origin of this artery, so now need only consider the course and branches. The course and relations show very little variation, except that the vessel may be carried upward by a cervical rib, Adams (1839), Halbertsma (1856), Fischer (1858), or the relation to the scalenus anticus may be disturbed; it may perforate the muscle, Knox (1843), Quain (1844), Wood (1867); it may form a ring around the muscle, Beck (1846), Hyrtl (1853), Schwegel (1859) 3:140; the latter I have observed three times. It may pass in front of the muscle, a condition I have observed only once, but which is generally more frequent, Manec (1832), Lizars (1834), Hird (1837), Velpeau (1839), Demeaux (1841), Cruveilhier (1852), Beck (1846), Duval (1853) .5 per cent., Schwegel (1859) .3 per cent., Luschka (1862), Bochdalek (1867), Romiti (1905).

Papers by Bean (1904) and Pellegrini (1906) represent the most extensive recent work on the subclavian. The former attempts to reduce his data to types which, with variables of this nature, must not only be unsatisfactory, but misleading, in that it suggests sharp definition between variations instead of the gradual

shiftings actually revealed by measurements. Pellegrini uses graphs which suggest quantitative study, although none was attempted. The branches of the subclavian show such a wide variation in their arrangement and the shifts of origin are so gradual and independent of each other it seems best to follow the plan of the earlier writers and treat each branch separately.

It is difficult to establish the number and identity of branches. Pellegrini found that there could be as many as 12 separate branches and placed the normal number as 10. Bean found the number of branches greater in adults than in infants, due, apparently, to the grouping as axes in the latter; he also found a difference in arrangement between the two sides. I found that the weighted average number of branches in my series was 4:93, representing a wide variety of combinations and dissimilarity between the right and left sides.

### *A. Vertebralis*

See Study, 1916, p. 41.

### *A. Mammaria Interna*

This artery is constant, but shows wide variations of origin and relations to other vessels. It may arise from the aorta or innominate, Neubauer (1722), Boehmer (1741), Walther (1785), Meckel (1816), Tiedemann (1822), Gruber (1872). In this series the condition was observed twice in the same cadaver; there was a second artery on the right with normal origin. The artery may arise lateral to the scalenus anticus and pass either ventral or dorsal to it, Münz (1821), Lauth (1833), Labatt (1837), Quain (1844), Nuhn (1849), Schwegel (1859), Power (1860), Gruber (1872).

Its course in the chest in relation to the border of the sternum shows a variation from 5 mm. to 35 mm. Its intercostal branches in their number, extent and anastomoses show a wide latitude.

A lateral internal mammary was described by Otto (1824) under the name of ramus costalis lateralis. It may spring from the subclavian as a separate branch or from the internal mammary, or, as in a case I encountered, it may spring from the third portion of

the subclavian and the internal mammary may be a branch of it. There is some confusion in terminology, but the vessel described as the accessory internal mammary, the lateral internal mammary, and internal thoracic seems to be this vessel, Heister (1730), Tiedemann (1822), Quain (1844), Hodges (1858), Hellima (1862), Hyrtl (1873), Walsham (1880), Paterson (1883), Carrington (1883), Stricheisen (1886), Souligoux (1894), Morestin (1894), Hepburn (1899), Bean (1904).

### *A. Thyreoidea Inferior*

The vessel shows great variation in origin and the disagreement between different studies is so great that it seems unnecessary to arrange the different results for reference. In my series it was absent in 1 per cent., arose as a separate trunk from the subclavian in 12 per cent., and from the common carotid in 2 per cent. Dwight (1888) found it very inconstant in its relation to the recurrent laryngeal nerve. I have twice seen it pass in front of the common carotid after originating from the thyrocervical trunk. Livini thinks that the great number of variations have their counterpart in the lower animals. Variations are reported by the following:

Barclay (1812), Quain (1844), Hilleret (1845), Broca (1850), Barkow (1851), Isaacs (1855), Luschka (1862), Bankart (1869), Carver (1869), Todaro (1877), Anderson (1879), Woefler (1879), Coues (1880), Carrington (1883), Kocher (1883), Rotter (1885), Onadi (1886), Dwight (1888), Shepherd (1889*a*), Brady (1891), Macalister (1892), Varaglia (1890), Thomson (1890), Delitzin (1899), Shimonek (1902), Bean (1904), Meoni (1904), La Rocca (1906), Pellegrini (1906), Neuberger (1912), Jenny (1911), Casali (1912).

### *A. Cervicalis Ascendens*

This artery has been considered as a branch of the inferior thyroid by some authors. Bean studied and figured it, but did not give it a separate discussion. Pellegrini found it present in 99 per cent. and as a branch of the thyroid in 85 per cent. He pointed out that, while it tended to combine with some other vessel in origin, it was slightly more constant than the thyroid. I found it present in all cases examined, and when the inferior thyroid arose

from the subclavian or the carotid it occupied the same position on the axis that the thyroid usually does; it was occasionally double and never sprung from the subclavian independently.

### *A. Cervicalis Superficialis*

It is somewhat more difficult to classify than the preceding. Bean found a branch of the transverse cervical in 60 per cent., while Pellegrini reported it a branch of the thyrocervical trunk in 78 per cent. I have found it most frequently a branch of the thyrocervical trunk, 76 per cent., though not infrequently as a common trunk of a few millimeters length with the transverse cervical. In all cases but one when the latter arose from the third portion of the subclavian the superficial cervical arose from the thyrocervical trunk. It was absent in 3.5 per cent.

### *A. Transversa Scapulæ*

Although the transverse scapular may arise from the third portion of the subclavian, 6 per cent., or from the axillary .5 per cent., Pellegrini 9 per cent., authorities agree in associating it with the thyrocervical trunk, 70 per cent., Pellegrini 61 per cent., Bean 70 per cent. It may be absent 4 per cent., or more frequently be small and only represented in its sternal and acromial branches.

### *A. Transversa Colli*

Pellegrini found it arising from the axillary in 5 per cent. and in 39 per cent. as a separate branch of the subclavian. Pearsol considered it normally as an independent branch from the third portion of the subclavian, as did Henle, Gegenbauer, and Sappey; Testut called it the posterior scapular. I found it in common with some other cervical branch in half the series. The posterior scapular was quite constant, 93 per cent., but while it was most frequently associated with the transverse colli, 80 per cent., it was found with the transverse scapular, profunda cervicalis, and as a separate trunk, Pye-Smith (1871), Coues (1880), Collins (1886).

### *A. Intercostalis Suprema*

This vessel was constant in my series, Sebastian (1847), Pensa (1905), Luna (1908). It may spring from a common trunk with

the vertebral, Quain (1844), Bean (1904), Pellegrini (1906); or from the second intercostal, Barkow (1868), Carrington (1883), Sebastian (1874), Poynter, both sides in one subject; or it may be multiple, Paterson (1883), Mears (1887). Carrington reported its absence.

### *A. Cervicalis Profunda*

It may arise from the internal mammary, Hyrtl (1841); or from the vertebral, Leroux (1851), Pellegrini (1906); or the inferior thyroid, Bean (1904) 4 per cent., Poynter 2 per cent.; or as a separate branch of the subclavian, Pellegrini 10 per cent. The description of a costocervical trunk is attributed to Lauth (1833), but was recognized by many before that time; Pellegrini found a trunk present in 89 per cent., Bean reported 54 per cent. on the right and 38 per cent. on the left, my series yielded a trunk frequency of 64 per cent.

### *A. Scaleni*

An artery to the scalenus anticus arising from the subclavian was described by Stahel (1886), but was figured by Quain (1844), page 181. Pellegrini found it present in 72 per cent., Bean did not speak of it, and in 50 bodies which I examined particularly for it I found a separate small branch, which might be interpreted as this artery, in 20 per cent.

## ARTERIES OF THE UPPER EXTREMITY

### A. AXILLARIS AND ITS BRANCHES

Since the division between the subclavian and axillary is an arbitrary one, the cases reported, in which the rami belonging to the subclavian come from the axillary, are no different, except in degree, than those variations already discussed.

Hyrtl (1839), from an examination of four embryos, concluded that the brachial divided proximally to the elbow and later moved distally, so making a high division a condition of arrested development. Duvernoy (1875) made a somewhat similar mistake in considering a superficial brachial, which he found in a six months' fœtus, a normal stage of development. There is not space to re-

view all of the work on development which has a bearing on the problems of these anomalies, but it may be largely covered by consulting the following: Baader (1866), Hochstetter (1890), Zuckerkandl (1894–6), DeVriese (1902), Müller (1902–4–8), Goeppert (1905–8–10), Elze (1913), Evans (1908).

Ruge (1884) was the first to attempt to arrange these variations in order, and this was very much improved by Schwalbe (1898), based on his comparative work and the developmental studies of Zuckerkandl. Whatever evidence we may have of an early indifferent network of capillaries, it is certainly true that somewhat later a definite circulation is laid down, and it seems that it is in connection with this circulation and its elaboration that we must look for the explanation of the anomalies. We must consider the scope of the variations and designate part of them as simply quantitative, Mehnert (1896). Fischel (1896) and Schwalbe (1898) have shown that even in the earliest embryos there is a large degree of individual variation in embryos of the same litter. In explaining any single variation we must look for a series of steps of sufficient breadth to eliminate the individual features and study a sufficiently large series to be sure of their constancy.

Much of the literature of axillary anomalies relates to high division of the brachial and other variations of the terminal arteries, consequently the plan already used of considering individual arteries will be followed.

It is not possible to explain all of the various anomalies on an exact embryological basis, due to lack of exact embryological data, but it would seem safe to follow DeVriese (1902) in assuming a secondary plexus for this region. Such an assumption agrees very well with the wide arrangement of branches which we must consider normal for this region. Careful measurements show that there is no such thing as arbitrary types and any attempt to force such a classification, while convenient for description, does not represent actual conditions.

As the first branch from the axillary, Pellegrini found a branch to the serratus anterior present 20 per cent., I found it in 42 per cent.

### *A. Thoracalis Suprema*

This was present in 90 per cent. of my series and in 10 per cent. it sent a branch to the second interspace; when absent, it was represented in the lateral thoracic .5 per cent. and in the acromio thoracic 2.5 per cent.

### *A. Thoracoacromialis*

This was the second branch in 47 per cent., was quite constant in its point of origin, averaging 42 mm. from the beginning of the artery. It sent a separate branch to the pectoralis minor in 8 per cent. It had a common origin with some other artery in 24 per cent.

### *A. Thoracalis Lateralis*

It arose from the thoracoacromial in 12 per cent. and from the subscapular in 8 per cent. In 24 per cent. it was double. The distribution to the intercostal spaces was irregular, in 15 per cent. the second space received no supply, while in 17 per cent. a separate branch from the axillary supplied this space.

### *A. Subscapularis*

This is the most constant branch of the group. It may come off with the thoracoacromial, 6 per cent. Generally the circumflex scapular and thoracodorsal are given off in the order named, but in 12 per cent. the latter appears first; in 4 per cent. the circumflex scapular is a separate branch from the axillary. The posterior humeral circumflex is a branch of the subscapular in 10 per cent. and the profunda brachii in 2 per cent.

### *A. Circumflexa Humeri Anterior*

It is usually small, it is double in 8 per cent., and is the last branch of the axillary in 35 per cent.

### *A. Circumflexa Humeri Posterior*

This arises by a common trunk with the anterior in 20 per cent., Quain 6 per cent., Pellegrini 22 per cent., Hitzrot 16 per cent. It is associated with the subscapular in 10 per cent.

### *A. Profunda Brachii*

This artery arises from the axillary as a separate branch or in conjunction with the circumflexæ or the subscapularis in 19 per cent.

Pellegrini gives the number of axillary branches as 11. In addition to the branches above enumerated, I found a branch, which may be designated as the capsular, which is present in 40 per cent. The following references to axillary variations have been collected:

Zagorsky (1809), Bintot (1827), Quain (1844), Tiedemann (1846), Dubrueil (1847), Schwegel (1859), Hyrtl (1864), Bankart (1866), Carver (1869), Pye-Smith (1871), Carver (1875), Nussbaum (1870), Walsham (1880), Hepburn (1895), Ruge (1884), Schwalbe (1898), Hitzrot (1901), Pitzorno (1903), Pensa (1905), Pellegrini (1906), Pohlman (1908), Dallest (1907).

### *A. Brachialis*

The anomalies of the brachial are all explainable on an embryological basis which has been so generally recognized that it need not be repeated here. In classifying the cases collected the plan employed by Müller (1903) has been followed.

Classification of Arm Artery Variations

I. Brachial artery passes in front of the median nerve and continues as:
   - *A.* Arteria brachialis superficialis superior.
   - *B.* Arteria brachialis superficialis inferior.

II. Double brachial, *i.e.*, superficial and deep:
   - *A.* Brachialis superficialis superior.
   - *B.* Brachialis superficialis inferior.

   1. Superficial and deep reunite.
   2. Superficial continues as the radial,
      - *a.* without anastomosis,
      - *b.* with anastomosis.
   3. Superficial brachial continues as
      - *a.* Ulnar,
      - *b.* Median,
      - *c.* Ulnar and Median.
   4. Superficial brachial as the radial and superficial antibrachial.

Group I, *A.* The brachial is double, consisting of deep and superficial branches, and, as suggested by DeVriese (1902), the superficial branch, which develops early, is the homologue of the

superficial brachial described by Bayer (1893) for monkeys; it was recognized by Haller as the vasa aberrentia. In these cases when the superficial brachial persists it terminates in the upper part of the radial, the ulnar, or the distal part of the brachial trunk. Cases by:

Ludwig (1767), Münz (1821), Quain (1828), Green (1830), Cruveilhier (1834–5), Demeaux (1843), Quain (1844), Tiedemann (1846), Gruber (1852), Carver (1869), Gruber (1870), Pye-Smith (1871), Foltz( 1872), Davies-Colley (1873), Charles (1874), Bankart (1874), Dean (1880), Shepherd (1880), Collins (1886), MacKay (1889), Mauclaire (1895), Carson (1895), Schwalbe (1898), Brême (1899), Lawrence (1900), Peronny (1902), Müller (1903), Farrari (1903), Herrington (1905), Galinos (1907), Pohlman (1908–9), Fontan (1911), Svenson (1916), Poynter 9 cases.

Group I, *B*. The profunda has dropped out and the superficial brachial has persisted as the single trunk of the arm. Chassaignac (1834), Cruveilhier (1835), Dubrueil (1847), Gruber (1852), Duval (1853), Blazina (1844), Schwegel (1859), Bourgery (1836), Schwalbe (1898), Müller (1903).

Group II, *A*. The brachial is double and the superficial brachial continues as the radial. This condition is generally known as high origin of the radial and is the most common of all the arm anomalies. As Müller has shown, developmentally the superficial brachial consists of three parts and this fact explains the variations in the origin of the radial from the axillary to the lower third of the arm. Examples have been described by the following:

Fabricius (1754), Eschenbach (1755), Morenheim (1783), Meckel (1816), Tiedemann (1822), Bintot (1827), Thierry (1827), Lauth (1833), Bourgery (1836), Petrequin (1837), Rendu (1841), Vergez (1842), Quain (1844), Dubrueil (1847), Broca (1849), Gruber (1849), Parmentier (1850), Didion (1850), Langer (1851), Gruber (1852), Michel (1855), Isaacs (1855), Reinhardt (1856), Maestre (1864), Patruban (1866), Oeffenger (1867), Petit (1867), Carver (1869), Parisot (1869), Pye-Smith (1871), Foltz (1872–3), Charles (1873), Davies-Colley (1873), Charles (1874), Robin (1874), Dean (1880), Thomson (1883), Giacomini (1884), Giuria (1888), Savariaud (1894), Souligoux (1893), Hawthorne (1895), Lafite (1898), Brême (1899), Schwalbe (1898), Balli (1903), Müller (1903), Borguet (1905), Georgigevriski (1906), Pitzorno (1907), Fontan (1911), Vilhena (1913), Svenson (1916), Poynter.

Group II, *B*. The brachial is double and the superficial brachial continues as the ulnar. Cases are reported by the following:

. . . . . .

Group II, 1. The brachial is double and the superficial brachial continues as the median or interosseus. In these cases the normal brachial divides into the radial and ulnar in the regular way. The condition is much less frequent than the two preceding classes and represents a dropping out of the connection between the ulnar and the median, Barclay (1812), Rendu (1841), it was combined with a recurrent ulnar, Barkow (1851), Parisot (1863), Gruber (1867), Lagrange (1882), Schwalbe (1898), Brick (1910), Hoskins (1914).

Group II, 2. The brachial is double and the superficial brachial continues as the radial and ulnar, the profunda as the interosseus. Rendu (1841), Foltz (1872), Lauth (1833), Quain (1844), Gruber (1852–67), Giacomini (1884), Lagrange (1882), Carrington (1883), Souligoux (1893), Gerard (1905), Vilhena (1913), Poynter.

Meckel (1816), Lauth (1833), Cruveilhier (1834–5), Quain (1844), Gruber (1852), 2: 440 arms, Tiedemann (1846), Gruber (1870), Parisot (1869), Pye-Smith (1871), Foltz (1872), Charles (1873), Humbert (1873), Tischansoff (1873), Walsham (1880), Collins (1886), Mackay (1889), Souligoux (1895), Schwalbe (1898), Brême (1899), Müller (1903), Bussiere (1904), Vilhena (1913), Poynter 2 cases.

Group II, 3. The superficial antibrachial radial may be present either as a continuation of the superficial brachial or from the profunda brachii. Dubrueil (1847), Dursy (1861), Gruber (1864), Turner (1878), Barkow (1851), Walther (1886), Schwalbe (1898), Susslow (1903), Stadnetski (1907), Brick (1909).

Group II, 4. Superficial antibrachial persists. Lucas (1838), Gruber (1867) ulnar double, Schwalbe (1898), Wynkoop (1899), Brême (1899), Müller (1903), Susslow (1903) ulnar double.

A large number of variations in the branches about the elbow have been reported, but in the light of DeVriese's work they are readily accounted for, and, on the other hand, until a careful study is made of a large number of arms to establish a normal range

they will be of slight significance, so are omitted from this study.

The processus supracondyloideus deserves no attention here except for the fact that it at one time was associated with arterial variations of the arm. It was first described by Otto (1838), then Patruban (1866). Gruber studied it particularly and established its frequency as 2.7 per cent. Ruge (1884) refers to it as related to high origin of the radial.

A summary of the larger studies quoted above represents 3,337 arms and yields a variation percentage of 19.8.

## ARTERIES OF THE HAND

It has been shown by DeVriese (1903) that the hand is vascularized early, and that there is a shift from the median artery, which is the oldest, to the interosseus, and finally this is replaced by the ulnar and radial as the trunks supporting its circulation. These shifts permit wide variations which are observed in the palmar arches and their connections. The arch supplied by a comes nervi mediani is interesting as representing a persistence of the earliest embryonal condition. Cases have been observed by Haller (1753), Ludwig (1767), Munz (1821), Tiedemann (1822), Bonamy (1834), Blandin (1834), Theile (1841), Quain (1844), Dubrueil (1847), Meyer (1848), Gruber (1852), Hyrtl (1862), Oeffinger (1867), Gerard (1897), Brême (1899), DeGery (1902), Bussiere (1904), Poynter.

Jastschenski (1890) made a very careful study of the arches of 200 subjects and furnished the following statistical data: Deep arch lacking once; superficial arch lacking 32 per cent. When the arch was present it was made up, radio-ulnar 27 per cent., ulnar 38 per cent., medio-ulnar 3 per cent., radio-medio-ulnar .5 per cent. Other observations on anomalies in the hand are by: Tiedemann (1822), Heister (1744), Lauth (1833), Green (1830), Bourgery (1830), Labatt (1838), Quain (1844), Dubrueil (1847), Barkow (1851–69), Dursy (1861), Hyrtl (1864), Reader (1866), Oeffinger (1867), Chuquet (1876), Rodet (1875), Mengazzini (1886), Jastschenski (1896), Schwalbe (1896), Salvi (1898), Bourguet (1904), Poillet (1904).

## ARTERIES OF THE THORAX

### AORTA THORACALIS AND ITS BRANCHES

In addition to the variations previously reported, Hepburn (1895) reports a right bronchial artery from the aortic arch, Walsham (1880) one from the subclavian, and Bean (1853) a supernumerary vessel.

The intercostal arteries may arise from a single common stem for the two sides or may be double in each interspace, Hellima (1861), Walsham (1881), Ernst (1900), Bühler (1904).

### ARTERIA PULMONALIS

These anomalies seem to be generally connected with developmental disturbances of the lungs and consist of an accessory artery from the aorta. McCotter explains the condition as the persistence of an early capillary plexus. References by Huber (1777), Maugars (1802), Rektorzik (1861), Cleland (1869), Allen (1881), Nicolle (1887), Laval (1901), Meloy (1908), Simpson (1908), McCotter (1910), Doereng (1914).

## ARTERIES OF THE ABDOMEN

### AORTA ABDOMINALIS AND ITS BRANCHES

#### *A. Phrenica Inferior*

These arteries present a variety of variations. In my series they arose by a common trunk in 55 per cent., in conjunction with the cœliac axis in 18 per cent., and in 5 per cent. they were associated with the suprarenal or renal vessels. References: Walther (1729), Haller (1747), Murray (1798), Sabatier (1791), Lauth (1833), Quain (1844), Dubrueil (1847), Cavasse (1856), Luschka (1862), Horrocks (1884), Rossi (1904), Branco (1912).

#### *Aa. Lumbales*

These arteries are recognized as dorsal segmental vessels and show anomalies depending on such origin. A vessel may be lacking and the area will be supplied by adjacent trunks or several

vessels will arise from a common stem. Broman (1908) thinks that the latter occur through fusion rather than atrophy of one of the trunks. The number of lumbar trunks will depend upon the interpretation of the intercostals. Haller, Theile, and Sabatier consider the last thoracic the vessel between the 11th and 12th thoracic vertebra, while Soemmering, Weber, and Poirier call the subcostal the last thoracic; with the latter Levi (1902) agrees and so considers that there is no 5th lumbar. In 20 per cent. of a series of 40 bodies I examined the 4th lumbar was irregular in origin, varying from an origin in common with the second lumbar to one from the lateral sacral or directly from the hypogastric. In 3 cases the 4th lumbars came from a common trunk from the right common iliac. In 6 cases symmetrical vessels which must be interpreted as 5th lumbars arose from the middle sacral. These figures agree quite closely with those of Levi. Ernst (1900) reports all of the intercostals and lumbars arising by a common stem for each segment.

### *A. Sacralis Media*

Young (1898) considers that this artery is not the continuation of the aorta, but his conclusions have not been well received, Broman (1908). This vessel may spring from the 4th lumbars or they from it, Young, Levi (1902), Thomson (1894) 9 per cent., Poynter. Other variations have been analyzed by Thomson for 400 bodies and Broman has very fully discussed the embryology of its variations.

### *A. Cœliaca*

This artery shows a marked tendency to irregular arrangement and its anomalies have created a wide interest. The most extensive study was made by Branco (1912), and other papers deserving special mention are those of Rossi e Cava (1904), Leriche et Villemin (1907), Descomps (1910), Piquand (1910), Eaton (1917), and Lipschutz (1917).

Our knowledge of the development of the vessels rests on the work of Frederic (1898), Mackay (1889), and Tandler (1904). The latter has shown how four trunks from the ventral aspect of the aorta form a longitudinal anastomosis, and from this the cœliac complex and the superior mesenteric are formed. From this it is

readily seen how the dropping out of one connection will produce a certain arrangement of the adult pattern.

The following table, arranged according to Branco, illustrates the percentage frequency of the variations commonly encountered:

| Name | No. Observations | Cœliac Trunk Complete | Cœliac Trunk Incomplete | Cœliac-Mesenteric Trunk | No Trunk |
|---|---|---|---|---|---|
| Rossi | 102 | 84% | 11 | 2.5 | 2.5 |
| Leriche | 55 | 84 | 9 | 1 | 0 |
| Descomps | 50 | 88 | 12 | 0 | 0 |
| Branco | 50 | 89 | 8 | 2 | 0 |
| Picquand | 50 | 82 | 14 | 2 | 2 |
| Lipschutz | 83 | 72 | 25 | 3 | 0 |
| Eaton | 206 | 90 | 9 | 1 | 0 |
| Poynter | 160 | 89 | 9 | 2 | 0 |
| Totals | 756 | 86 | 11.8 | 1.4 | .4 |

While this table does not list all arrangements that have been reported, it seems useful in showing that the variations from a three-branched cœliac artery and separate superior mesenteric will fall within 14 per cent.

### *A. Gastrica Sinistra*

This artery varies in the number of its trunks, but more particularly in its origin. Rossi found the artery arising directly from the aorta in about 5 per cent. and Eaton states the average for his series as 6.7 per cent. In my series I found only two cases of this condition. Vesalius and his school consider that the artery is normally a branch of the splenic. This was corrected by Winslow (1832). Numerous reports have been given of this vessel associated with the hepatic or an accessory hepatic.

### *A. Lienalis*

This artery is the most regular of the group. It may arise from the aorta independently, Quain (1844), Dubrueil (1847), Rossi (1904), and Krause reports a case of Hyrtl's in which it arose from the superior mesenteric.

### *A. Hepatica*

This vessel shows more irregularities than any other of the group. It may be double. Rossi found an accessory branch to the left lobe 21 times in 102 bodies, and I have seen the same number in 160 subjects and 12 cases in which the right branch was double. Sussloff (1907) found the left branch present 17 times and the right double 9 times in 131 subjects. Other cases of aberrant arteries are reported by Walther (1729), Petsche (1736), Haller (1746), Rudolph (1781), Barkow (1868), Dupis (1874), Jacquemet (1894), Guibe (1901), Gentes (1906), Branco (1912), Budde (1906), Lipschutz (1917).

The condition of three hepatic arteries is a rarer condition. I have encountered it only once, in which case a branch to the right lobe and one to the left arose from the cœliac, while a second branch to the gall bladder came from the superior mesenteric. Other cases are reported by Tiedemann (1822), Meckel (1825), Green (1830), Lauth (1833), Labatt (1837), Dubrueil (1847), Barkow (1868), Rolleston (1889), Franz (1896), Brewer (1903), Budde (1906), Gerard (1914).

Four vessels have been recorded by Lauth (1833), Cruveilhier (1841), Rossi (1904), Budde (1906).

The hepatic may arise from the superior mesenteric, a condition which is very interesting morphologically, but which is readily accounted for developmentally. See cases as follows: Mayer (1783), Quain (1844), Barkow (1868), Davies (1873), Farabeuf (1885), Hochstetter (1886), Struthers (1892), Tandler (1904), Rossi (1904), Hecht (1905), Leriche (1907), Sussloff (1907), Gentes (1907), Piquand (1909).

The hepatic may arise normally from the cœliac, or the aorta and an accessory artery may spring from the superior mesenteric, or an anastomosing trunk between the two.

Walther (1731), Nicolai (1732), Petsche (1736), Hensing (1742), Heuermann (1753), Gunz (1757), Haller (1764), Sandifort (1777), Mayer (1783), Caldanes (1810), Lauth (1833), Barkow (1868), Brown (1879), Hochstetter (1886), Dunn (1890), Rolleston (1890), Elworthy (1891), Struthers (1892), Jacquemet (1894), Franz (1896), Chomet (1897), Rauber (1897), Wiart (1899), Cavalier (1900), Geraudel (1901), Bühler

(1904), Rossi (1904), Broman (1905), Budde (1906), Leriche (1907), Susloff (1907), Kuss (1909), Piquand (1909), Branco (1912), Lipschutz (1917).

### *A. Mesenterica Superior*

As already stated, the superior mesenteric artery should be considered developmentally as a part of the cœliac complex, consequently its anomalies are largely connected with that artery and have already been referred to, particularly under the hepatic. Its connection with the omphalo-mesenteric was observed by Haller (1747). The artery may arise entirely from the cœliac or may have a persistent root from it. I have encountered this condition 4 times, Barclay (1812), Tiedemann (1846), Cavasse (1856), Streets (1872), Struthers (1892), Jacques (1895), Franz (1896), Bühler (1904), Rossi (1904), Tandler (1904), Brunin (1905), Leriche (1907), Sussloff (1907).

A connection may be established with the inferior mesenteric by which the colica sinistra becomes a branch of the superior, Dubrueil (1847), Fleischmann (1815); or the colica media may spring from the splenic, Davies (1873).

### *A. Mesenterica Inferior*

This artery has apparently not been carefully observed, for there is scant reference to it in literature; it seems, however, to be a very stable branch. Cavasse (1856) saw an accessory hepatic as one of its branches and occasionally it furnishes renal branches. Vicq D Azyr (1776) noted the absence of a connection between the colica media and sinistra. I have seen one case in which the colica media was derived from it as a large branch arising near its origin.

### *A. Suprarenalis*

A very complete study of these arteries was made by Gerard (1913). He found that the inferior suprarenal usually springs from the renal, but it may be associated with an accessory renal or with the inferior phrenic, or with the spermatic. It is not infrequently multiple. Gerard recognized a middle capsular artery which arose from the aorta in 85 per cent. of the series.

The superior suprarenal is frequently multiple; it has been re-

ported as a branch of the cœliac artery. These observations agree quite closely with those of Levi (1909), who studied 96 bodies.

### *A. Renalis*

Bremer (1915) made a study of the development of the renal circulation and found an early preaortic plexus from which he concluded that the renal arteries are derived through mechanically selected channels. He applied this idea to the explanation of the anomalies which are so frequent. He opposed the idea of the development of late branches. Both renal arteries may spring from a common stem, Portal (1803), Dubrueil (1847).

The most frequent anomaly is an increase in the number of arteries to the kidney. These variations have long been recognized. Murray (1798) said: "The anatomists said that there was such a variety both in number and position of this artery as to make it without profit to enumerate them."

The number of arteries varies from two to six, the most frequent being two. An accessory artery to the lower pole is more frequent than to the upper; not infrequently two small arteries to the hilus take the place of the normal single vessel or the artery may be double for a short distance. Usually the accessory artery springs from the aorta, but may have an origin from various other sources, as: suprarenal, Gerard (1913), Poynter; cœliac artery, Macalister (1883), Gillepsie (1916); superior mesenteric, Kolster (1902), Gillespie (1916), Poynter; inferior mesenteric, Cavasse (1856), Macalister (1883); the common iliac, Quain (1844), Barkow (1851), Pilate (1867), Glason (1868), Hyrtl (1868), Dufour (1852), Davies-Colley (1873), Macalister (1883), Tuffier (1886), Brodie (1893), Hepburn (1891), Thomson (1890), Mahon (1889), Tonkoff (1903), Young (1903), Kater (1901), Roussy (1904), Bouteil (1909), Harvey (1914), Poynter; from the middle sacral, Bonnet (1835), Otto (1830), Hyrtl (1841), Barkow (1851), Struthers (1892), Macalister (1883), Londe (1890), Harding (1898), Brodie (1893), Poynter; from the external iliac, Macalister (1883), Tonkoff (1903).

From study of the literature I find no difference in frequency between the two sides, and the number of bilateral conditions con-

stitute about half of the cases. The anomaly seems to be uninfluenced by sex, and there seems to be no relation between supernumerary arteries and veins; the latter is the rarer anomaly.

There is a wide discrepancy in the text-books as to the frequency of multiple renal arteries which the following table may help to clear up:

| Name | Date | No. Studied | No. Examples | Percentage |
|---|---|---|---|---|
| Macalister | 1883 | | | 43 |
| Carlen | 1893 | 200 | 38 | 19 |
| Schmerber | 1895 | 200 | 28 | 14 |
| Thomson | 1890 | 419 | 107 | 25.6 |
| Kolster | 1902 | 206 | 54 | 26.2 |
| Kubo | 1907 | 100 | 15 | 15 |
| Levi | 1909 | 192 | 57 | 35 |
| Rupert | 1913 | 100 | 44 | 44 |
| Gillespie | 1916 | 66 | 39 | 59 |
| Poynter | | 400 | 64 | 16 |

The larger percentages of the table include the cases in which the renal vessel divides into two or three branches just before entering the kidney.

The following report five or more accessory arteries: Macalister (1883), Mahon (1889), Kater (1901), Jolly (1896), Young (1903), Kubo (1907), Gray (1906), Poynter.

### *A. Spermatica Interna*

It has been reported lacking, Bartholin (1654), and double, Gerard (1913). It shows a wide range of origin not alone along the aorta, but from its branches, Barkow (1868), Hyrtl (1873), Krause (1876), Kolster (1902), Gerard (1913), Rupert (1913), Stopford (1913).

Kolster found the origin from the renal artery not infrequent. Accessory spermatics have been reported by Hughes (1892) and by Pohl (1773); I saw one case that was double for about half its length, having one root from the renal and the other from the aorta.

## ARTERIES OF THE PELVIS

### A. ILIACA COMMUNIS

The iliacs are the proximal persistent portion of the umbilical arteries. A number of observations have been made in which one of the umbilical arteries was lacking in the cord, Fleischmann (1815); or was obliterated, Bremer (1906). Mouchotte (1900) reported finding no artery on the left distal to the hypogastric, which was rudimentary. Other cases were reported by Boudant (1828) and Tschaussow (1886), Duckworth (1907), see Argaud (1904). The umbilical situated in a deep fold of peritoneum was seen by Kelch (1803) and Otto (1830); Otto (1824) found the umbilical remaining patent to the umbilicus in an adult.

The common iliacs vary very much in length; data on this point may be found from the studies of Quain (1844), Thomson (1892), Levi (1902), Lipschutz (1918). The latter two found that the length does not depend on the point at which they join the aorta.

### A. HYPOGASTRICA

The hypogastric artery shows the same wide variation of branches as found in the axillary. In order to explain these anomalies, I made a study of the development of this vessel and its branches, using the embryos of the Harvard collection and those of Doctor Jackson at Minnesota University, together with my own. The following statement is taken from an unpublished paper based on that work.

Young (1898–1900) presented the hypothesis that the umbilical arteries represented continuations of the aorta, and that the curved aspect represented a caudal arch corresponding to the aortic arches. This idea overlooks the mechanism of shifting of the branches of the abdominal aorta which Tandler (1903) and Broman (1908) have so definitely established.

An early 9th day rabbit embryo, Harvard No. 620, shows an extensive plexus in the caudal region, vittilenæ, before any definite channels have been established between the unfused aortæ and the umbilical trunks. Very soon, 9½-day age, the plexus has given place to five or more roots of connection between the umbilicals

and the aortæ, H. No. 939. During the next 36 hours of development the picture remains the same, only new connections are being established caudally and the anterior ones are dropping out, H. Nos. 562 and 559. This condition has been figured by Felix (1910) and others for the human.

Before "Wanderung" is complete two or more small vessels spring from the most proximal portion of the umbilical arteries to supply the posterior limb buds, H. No. 560. Later these vessels can be identified as the two primary limb vessels. The more caudal vessel grows the more rapidly and soon seems to be the continuation of the aorta of which the umbilical is a branch, H. No. 658. I have not discussed the lateral shifting which Hochstetter first described in 1890.

The human embryo of the 11 mm. stage presents the condition just described in embryo No. 1658, except that the umbilical arteries are very much larger, Jackson embryo No. 68. About this stage, my embryo 12 mm. and Jackson No. 1, the hypogastrics present a condition of "Wanderung," so that the junctions of the umbilical and these vessels present broad areas of origin with numerous roots. This is much later than the appearance of the "abdominal plexus," 7 mm. stage, referred to by Senior (1919), which may have persisted, although I did not identify such a condition.

My embryo 14 mm. and Jackson embryo No. 60, same age, show the beginning of the pudendal and superior gluteal; these buds appear at the point of the "Insulbildung." By the 17 mm. stage, Jackson embryo No. 58, the lateral sacral has appeared and a branch passing medially toward the rectum. The latter is not constant and could not be found in some of the later stages. Generally by the 19 mm. stage all connections between the branches has disappeared so that each seems to arise separately from the umbilicals; the "Insulbildung" occasionally persists for some time as in the Jackson embryo No. 32 of 25 mm.

From a study of these steps of development and the subsequent stages up to 40 mm. it is evident that the way in which the different connections persist or drop out will determine the arrangements of the branches of the hypogastric.

### *A. Iliolumbalis*

These vessels develop somewhat later than those outlined above, but from the same plexus, so that they share in the irregularities of origin. Dubrueil (1847) reported it lacking. It has been repeatedly reported double and many anatomists have considered it a branch of the superior gluteal. Poirier and Levi both consider it a branch of the hypogastric, and with them I must agree, not only because of its development, but because in this series it arose independently in 72 per cent. It has been observed as a branch of the lumbars, sacra media, and more frequently of the lateral sacral.

### *A. Sacralis Lateralis*

These vessels show great irregularity in development and primarily are represented by two separate vessels, a superior and an inferior vessel. They are frequently associated with the gluteal in early development, a condition reflected in the adult statistics, Parsons (1897) 92 per cent. My series shows these arteries single 55 per cent., double 45 per cent., arising from the hypogastric 22 per cent.

### *A. Obturatoria*

This artery has attracted more attention than all of the rest of the group, due, no doubt, to the surgical interest connected with its origin from the epigastric. Almost every text-book on surgical anatomy goes into an extended explanation of its course and relations. It is not necessary to include all of the references to isolated reports of "an unusual anomaly of the obturator," but it seems desirable to present statistical evidence for the origin from the epigastric and cite those cases which seem to be unusual in other particulars. The first report I have been able to find is that of Haller (1745), note 9, who says, "Non tamen perpetuum est eam arteriam a pelves truncis nasci, eam novies ex epigastrica ortam." The surgical significance of the anomalous course seems to have been recognized by Monroe (1806). Very soon numerous statistics of frequency were made, which still influence our literature. Burns (1806) placed the frequency at 50 per cent., based on an observation of two cases; Velpeau (1832) studied 20 cases

and placed the frequency at 5 per cent. The first extensive study was made by Cloquet, which, with others, is given in the following table:

TABLE SHOWING THE PERCENTAGE FREQUENCY OF ORIGIN OF THE ORTURATOR ARTERY FROM THE EPIGASTRIC

| Name | Date | No. Obs. | Percentage | Male | Female | Right | Left |
|---|---|---|---|---|---|---|---|
| Cloquet | 1817 | 500 | 30.4 | 24.4 | 31.4 | | |
| Breschet | 1819 | 63 | 19 | | | | |
| Hesselbach | 1819 | 64 | 43.3 | | | 37.5 | 46.8 |
| Quain | 1844 | 360 | 31.4 | 33.9 | 29.8 | | |
| Schlöbig | 1844 | 112 | 21 | 28.4 | 34.2 | | |
| Isaacs | 1855 | 706 | 18.3 | | | | |
| Wyeth | 1878 | 52 | 34 | | | | |
| Hoffmann | 1878 | 400 | 32.5 | | | | |
| Hartmann | 1881 | 180 | 19 | | | | |
| Krusche | 1885 | 80 | 20 | 37.5 | 25.9 | | |
| Pfitzner | 1889 | 226 | 37.6 | | | 33.3 | 34.2 |
| Jastschenski | 1891 | 404 | 24 | 34.6 | 26.3 | 33.2 | 26.8 |
| Dwight | 1895 | 500 | 25 | 28.3 | 23.2 | 23.8 | 26 |
| Levi | 1902 | 200 | 25.2 | | | | |
| Poynter | | 400 | 26.2 | | | | |
| Total | | 4,044 | 25.1 | | | | |

The question of an anthropological influence was raised by Pfitzner and Dwight, but no definite conclusions can be drawn. We may conclude that the anomaly will be encountered in one case in four, that there is little sex difference, and that it is slightly more frequent on the left side.

So far no satisfactory embryological explanation has been made. From my study I find that the vessel develops late, 25–35 mm. stage, as a pelvic vessel and later passes out of the pelvis. Before it has left the pelvis it develops a retro-pubic branch of some magnitude; this may join a similar branch from the deep epigastric, but I have never established such a connection. In one embryo, 32 mm., I found a well-developed artery from the internal circumflex in the position of the extra pelvic portion of the obturator, a well-developed retro-pubic branch from the epigastric, and no evidence of an obturator within the pelvis. It would seem that the examination of a reasonable number of embryos of about 30 mm. stage should settle the mechanism of this anomaly.

The obturator may spring from the external iliac, Jastschenski 2 per cent., or from the femoral, Quain, Hughes (1892), Jastschenski, Levi. It may have two roots, one from the hypogastric and the other from the epigastric, Monro (1803), Münz (1821), Hesselbach (1819), Quain (1844), Tiedemann (1846), Broca (1849), Jastschenski, Lachi (1885), Delitzin (1896), Levi. A condition in which there is no connection between the intra and extra pelvic portions of the artery is reported by Green (1830), Hughes (1892), Duclaux (1902), Sussloff (1903).

### *A. Glutæa Superior*

The gluteal is the primary trunk from the hypogastric, developing slightly earlier than the pudendal. Cruveilhier and Theila thought it represented the continuation of the hypogastric. It is very constant in its course and distribution. It arises as an isolated trunk, Jastschenski 66 per cent., Lipschutz (1918) 57 per cent. Levi found that it passed behind the lumbosacral nerve in 10 per cent.

### *A. Glutæa Inferior*

This is the first trunk developed from the umbilical and the primary limb artery; when the connection is broken at the knee it falls behind in development and becomes a minor artery. It may run above the pyraformis muscle, Dubrueil (1847), Barkow (1851), Pye-Smith (1871). These cases probably represent a dropping out of the primary trunk and a secondary anastomosis with the superior gluteal. It may form a common trunk with the gluteal, Jastschenski 24 per cent., Lipschutz (1918) 43 per cent., or with the pudendal the former 49 per cent., the latter 43 per cent. Parsons (1897) reports the artery double and Streets has seen a connection with the obturator.

### *A. Vesicalis*

Poirier thinks that it arises in common with the prostatic, vesico-defferential, or middle hæmorrhoidal; Levi finds it as a separate trunk in 43 per cent., its place more frequently being supplied by other arteries; this agrees with others, Friedlowsky (1862), Gueillot (1883), Mougreide (1893), Parsons (1896).

### *A. Vesico-defferentialis*

This has been very fully studied by Fraenkel (1901) and Levi (1902); they find it a branch of the umbilical in 94 per cent., in other cases it springs from the prostatic and the pudendal. Henle (1868) and Tschaussow (1886) saw the vessel very large.

### *A. Uterina*

Nagel (1896) associated the artery with the hypogastric, the obturator, and the vesico-vaginal. Levi (1902) found it constantly a branch of the umbilical; this agrees with Souligoux (1894). He also reported that the artery passed 8 cm. from the ureter. Parsons (1896) found the artery a branch of the hypogastric in 50 per cent.

There is some disagreement on the terminal relations of the uterine and ovarian arteries which will require more investigation to settle. The different opinions are fairly represented by Henle (1868), Waldeyer (1895), Broeckhart (1802), and Souligoux (1894); the question is whether there is or is not a circulus arteriosum Huguieri. General studies of the artery have been made by Ricard (1887), Fredet (1899), Freund (1904), and Redlich (1909).

### *A. Hæmorrhoidalis Media*

Levi (1902) found it an inconstant branch, present in 67 per cent.; in the majority of cases it arose from the pudendal. Waldeyer attributed little importance to it.

### *A. Pudenda Interna*

This is the second trunk to develop from the hypogastric; it is not infrequently associated with other branches, as I have shown was the condition developmentally. Occasionally it leaves the ischiadic at the spine, Levi (1902). It may terminate in the perineal, while the artery to the external genitals may come from the obturator, Münz (1821), Green (1830), Labatt (1837), Schwegel (1859), or from the epigastric, Quain (1844), Friedlowsky (1868). More frequently the artery is associated with the inferior vesicle, Haller (1749), Friedlowsky (1869), Tschaussow

(1886), Saltzmann (1872), Wassiliew (1885), Pye-Smith (1871), Walsham (1880), Thomson (1884), Zuckerkandl (1900).

### A. ILIACA EXTERNA

The external iliac develops as the second branch of the umbilical, it varies in length. Henle thinks there is an inverse relation between its length and that of the common iliac, while Sappey thinks there is a relation between its length and the height of the bifurcation of the aorta. Levi (1902) finds that with the division of the aorta between the fourth and fifth vertebræ the length is 10–11 cm., while if the division is between the third and fourth the length is 9–10 cm. My figures agree with those of Levi. In cases where the ischiadic persists as the main artery of the limb it is poorly developed, Green (1830).

### *A. Epigastrica Inferior*

This artery was not understood till Mall (1898) worked out its development, but it has received much attention in literature on account of its relation to hernia. The artery shows a variation in its origin in relation to the inguinal ligament of 2–4 cm., Levi (1902). Long ago, Beckers (1813), it was shown that when it originated well under the inguinal ligament it passed medial to the hernial ring; others observing a medial course of the artery are Münz (1821), Monro (1842), Truestedt (1816), Verpillat (1834), Quain (1844), Tiedemann (1846), Honel (1848), Michaux (1848), Serofini (1903). I have recorded the condition 12 times in my series.

It has been observed originating from the obturator; Jastschenski (1891) thinks that a free anastomosis between its retro-pubic branch and that of the obturator is the means by which the latter becomes a branch of the former; l. c., Walsham (1880) calls attention to the epigastric originating from the obturator, which is not very rare, or the profunda, Monro (1813), Munn (1858), Baucat (1883). It may be double, Honel (1848), Spence (1855).

### *A. Circumflex Ilicum Profunda*

This artery may be lacking, Schwegel (1859). There is some disagreement as to the number of its branches. Stieda (1892)

reviewed the literature and made a complete study of the artery and its branches; he showed that occasionally a large lateral epigastric ran parallel to the inferior epigastric and might be a problem in abdominal paracentesis. Cases have been reported by Ramsay (1812), Dubrueil (1847), Quain (1844), Srb (1860), Gruber (1867), Stieda (1892). Levi (1902) confirmed Stieda's observations and also found an accessory artery in 10 cases.

## ARTERIES OF THE LOWER EXTREMITY

### A. FEMORALIS

For convenience of description the arteries of the lower extremity may be considered together. The comparative study of these arteries may be found by reference to Zuckerkandl (1895). In 1890 Hochstetter showed that the primary artery of the mammalian thigh was that accompanying the ischiadic nerve, and that the femoral took over the function somewhat later. Leboucq (1893) described the ischiadic artery in the human embryo. DeVriese (1902) gave the first systematic account of the development of the lower limb arteries in the human embryo. To this work Senior (1919) added a detailed account of the development of the popliteal portion of the axial artery and showed that the adult popliteal was made up of the proximal part of the embryonal popliteal (profunda) and the superficial popliteal. He disagreed with DeVriese as to the identity of the arteria interossea and peronea.

#### *Persistence of the Embryonal Axial Artery*

In these cases the inferior gluteal continues downward as the supply for the leg and foot, while the femoral terminates at the knee. Bell (1826), Green (1832), Cailliard (1833), Dubrueil (1847), Ellis (1853), Auzias-Turenne (1854), Fagge (1864), Hochstetter (1890), Pronant (1891), Manno (1906).

Auburtin (1905) has shown that the lateral circumflex is made up of a number of separate arteries which are represented by a common stem in 72 per cent., Lipschutz (1915) 75 per cent. Schwegel observed the obturator from the lateral circumflex. Pye-Smith observed the artery taking a very superficial course and also arising from the superficial femoral.

The circumflex media may be lacking and its defect supplied by the obturator, Pye-Smith. It may arise from the external iliac, Lipschutz 2 per cent.; from the inferior epigastric, Fischer (1827); or may be the source of the epigastric, Reid (1836).

*Arteria Saphena Magna.*—This artery is common to lower mammals. DeVriese saw a branch from the 10 mm. human embryo which she interpreted as this artery. When the artery persists it extends a variable distance between the knee and the medial side of the ankle. I have been able to collect the following cases: Zagorsky (1809), Broca (1849), Ruge (1863), Hyrtl (1864), Papowsky (1892), Ruge (1894), Salvi (1899), Papowsky (1904), Manno (1905).

The femoral variations are largely covered by arrest of development just given and a condition of double artery which is difficult to explain. The condition has been observed by Bell (1826), Houston (1827), Green (1832), Quain (1844), Tiedemann (1846), Dubrueil (1847), Ducachet (1863), Barkow (1868), Chretien (1880), Craig (1880), Griffith (1881), Kelly (1882), Bianchi (1889), Musgrove (1891), Willet, Ref., Musgrove.

*Femoral Branches.*—The point of division in relation to the inguinal ligament is variable. Quain found the mean distance 3.8 cm., and Adachi (1897) about the same. Mercier (1836), Zaaijer (1865), and Schrutz (1894) report a division immediately below the ligament. Lipschutz (1915) and Young (1878) find a total absence of the profunda, its branches coming directly from the superficial trunk.

The profunda femoral is sometimes given off laterally and sometimes medially. Srb (1860) thought its position depended on whether it furnished the medial circumflex or not; the lateral circumflex seems to draw the vessel laterally. The profunda may pass medially superficial to the vein, then continue in a normal way; such cases are reported by Mercier (1836), Cruveilhier (1843), Friedlowsky (1867), Zaaijer (1893), Adachi (1898), Lenrmant (1904), Johnston (1912). The latter offers as an explanation the presence of an early anastomosis superficial to the vein which he has found present in the dog and goat.

The branches of the profunda show a wide variation in their

arrangement. Lipschutz (1915) has made a comparative study of their arrangement and attempted to type them with the same unhappy results that similar efforts in other regions of wide variation have had. Observations have been made by Quain (1844), Srb (1860), Friedlowsky (1861), Gruber (1871), Faucon (1874), Schrutz (1894), Ruge (1894), Adachi (1896), Parsons (1898), Auburton (1905), Bluntschli (1907), Malenooski (1913).

### *A. Poplitea*

Senior (1919) concludes that the adult popliteal artery is made up of the proximal part of the primary embryonal vessel, and that in its distal part, in the position superficial to the popliteus muscle, it is formed of a second embryonal vessel which he designates as the superficial popliteal. The popliteal may be very short, dividing at the upper border of the muscle, Haller (1752), Münz (1821), Lauth (1833), Quain (1844), Tiedemann (1846), Hyrtl (1864), Dean (1880), Lane (1887), Robineau (1897), Farrari (1903), Dubrueil (1905). Quain (1844) found the artery double 10 times in 227, but did not think that it could be double above the joint; see Dean (1880), Collins (1886), Mackay (1889), and Croft (1861) for double artery proximally.

Robinson (1898) reports two cases in which the anterior tibial passed in front of the popliteus muscle, and a case by Green (1830) seems to be similar. The artery may be irregular in its course, passing through the inner head of the gastrocnemius, Labatt (1837), Croft (1861), Francois Franck (1873), Terrier (1873), Stuart (1878), Davidson (1890). It may pass behind the vein, Féré (1878). All of the terminal branches may be given off from a single point, Withers (1890). Otto (1824) reported a large branch which passed upward to anastomose with the last perforating artery.

### *A. Tibialis Anterior*

The artery may take a course around the lateral side of the fibula and follow the lateral aspect of the leg, Velpeau (1839), Quain (1844), Hyrtl (1864), Streets (1872), Baudet (1907). It may be lacking, Burns (1809), Otto (1830), Dubrueil (1847); or may fail to join the dorsalis pedis, Nélaton (1834), Quain (1844), Dubrueil (1847), Fano (1848), Gérard (1900).

The dorsalis pedis may be subcutaneous in its course, Gruber (1864), Poynter; or fail to unite with the plantar arteries, Broca (1849), Malgaigne (1842), Gruber (1864). It may be the continuation of the peroneus in those cases in which the anterior tibial is weak; this represents an early embryonal stage, Nélaton (1834), Salvi (1898), Bussiere (1904), Manno (1905), Trecomi (1906), Corsy (1913), Vilkena (1913). For a discussion of the tarsal arteries see Hyrtl (1864).

### *A. Tibialis Posterior*

It may be replaced by the peronea or saphena artery, for these are united by an anastomosis in an early stage of development. Its absence was noted by Quain (1844), Dubrueil (1847), Bradley (1868). Irregular plantar distribution was reported by Tiedemann (1822), Cruveilhier (1837), Hyrtl (1864), Pye-Smith (1871), Chevrier (1904).

### *A. Peronea*

Stieda (1893) expresses the opinion that the peronea is the axial artery of the leg. In 1894 Zuckerkandl agrees with this idea, but the next year, after an embryonal study, he concludes that the peroneal, which is separated from interrosseus membrane by the tibialis posterior muscle, can not be a derivative of the artery which lies in front of that muscle. Senior (1919 and 1921) finds that the ramus communicantis inferior from the peronea posterior superior joins the axial at the 18 mm. stage and the axial, interosseus of Zuckerkandl, proximal to it, drops out, so that the adult peronea is in part made up of the axial. DeVriese describes no such step in development and repeats the statement of Stieda. Allowing, then, for the development in the way that Senior has described, we may still look for an axial vessel for the lower limb.

Quain found the vessel strongly developed in 31 : 209 cadavers. Its absence was noted by Otto (1826), Lauth (1833), Barkow (1850), Carver (1869). The axial portion seems to have been lacking in the case of Hyrtl and the superficial proximal portion persisted in cases by Cruveilhier (1837), Lauth (1833), and Meckel (1816).

## VENÆ

The venous anomalies have not attracted the same attention as those of the arteries probably because of the apparently greater physiological significance of the latter. The wide range in venous pattern which may be called normal and the large number of anastomosing trunks makes it difficult to recognize those conditions which represent developmental irregularities. In satisfactorily accounting for these anomalies the same detailed history of the development is necessary which has been supplied in so many regions for the arteries and which as yet is not available. It must be kept in mind that the veins develop independently of the arteries, Hochstetter (1891), Zumstein (1895). Vena cometes is a secondary development and represents not only a late developmental stage, but also the disappearance, in the majority of instances, of the primary veins.

### VV. PULMONALES

Brown (1913) has shown in a 4.5 mm. embryo that the anterior cardinal veins and the pulmonary veins are connected with an indifferent capillary plexus. This fact undoubtedly accounts for the irregular connections found between the vena cava and these veins.

The upper pulmonary vein may open into the right superior cava or right atrium, Wilson (1798), Meckel (1820), Breschet (1819), Otto (1830), Cooper (1836), Chassinat (1836), Lacroix (1844), Taylor (1845), Lambl (1860), Foerster (1861), Duchek (1862), Hickman (1869), Gruber (1876–85), Gegenbauer (1880), Crocker (1879), Chiari (1880), Talini (1881), Toepley (1882), Chaffey (1884), Epstein (1886), Rokitansky (1875), Hepburn (1886), Miura (1889), Greenfield (1896), Shepherd (1890), Etlinger (1891), Birmingham (1893), Patterson (1913), Griffith (1898), Blondel (1901), Thiele (1903), Thane (1906), Ströber (1908), Looten (1910), Schroeder (1911), Merkel (1912), Brown (1913), Gérard (1914), Nützel (1914).

The upper left pulmonary vein may open into the left innominate or a persistent left cava, Johnston (1860), Blair (1901), Ingalls (1907), Patterson (1913), Nuetzel (1914), Johnston (1914).

VENA CAVA SUPERIOR

The embryological history of the vena cava has been repeated so many times it is unnecessary to outline it again. Anomalies are associated with the embryological pattern and consist of persistence of embryological connections alone or in conjunction with atrophy of normally developing channels. Ancel and Vellemin (1908) have classified the anomalies as follows:

*A.* Double superior vena cava without anastomoses. Persistence of the left duct of Cuvier and failure of development of the left innominate vein.

Bartholeni (1641), Kerckring (1670), Boehmer (1752), Haller (1768), Murray (1781), Wilson (1798), Ring (1805), Meckel (1802–05–17), Niemeyer (1814), Beclard (1816), Wese (1818), Cerutti (1822), Wehrde (1826), Breschet (1819), Houston (1827), Hesselbach (1834), Otto (1830), Serres (1830), Valleix (1834), Cooper (1836), Marchesseaux (1838), Hyrtl (1839), Martin (1841), Herberg (1845), Gruber (1846–59–65–81–84–), Marshall (1850), Chassaignac (1852), Luschka (1862), Peacock (1866), Chiene (1867), Humphrey (1867), Paterson (1868), Zaaijer (1869), Farmer (1874), Rokitansky (1875), Kadyi (1881), Rex (1882), Dilg (1883), Audry (1890), Pangratz (1894), Galubew (1895), Bauer (1896), Hahn (1896), Berens (1898), Broome (1900), Berthel (1901), Baumgarth (1902), Willige (1904), Gérard (1907), Ancel (1908), Merkel (1912), Atten (1913), Dietrich (1913), Cameron (1914), Johnston (1914), Beyerlein (1914), McCotter (1915), Poynter 3 cases.

*B.* Double superior vena cava with small anastomoses, persistence of the left duct of Cuvier, and a small innominate development.

Hyrtl (1839), Marshall (1850), Heppner (1863), Gruber (1864–81), Hepburn (1886), Hart-Smith (1894), Dalton (1899), McCotter (1915).

*C.* Double superior vena cava with normal innominate vein. Gruber (1865–85), Walsham (1880), Howden (1886), Cencel (1908).

*D.* Persistence of the left superior vena cava without atrophy of the right superior cava.

Cheselden (1713), Greenfield (1876), Gruber (1880), Little (1880), Mackenzie (1880), Halbertsma (1862), Weigert (1881), Charles (1889), Bédart (1892), Boyd (1893), Maussert (1899), Smith (1916).

Unclassified cases. Weber (1829), Leudet (1852), Furner (1874),

Turner (1874), Töpley (1882), Shattock (1883), Chaffey (1884), Eppinger (1890), Zander (1892), Galubew (1895), Tichomeroff (1895–98), Brin (1896), Fawcett (1897), Daser (1901), Kowalewski (1904), Hermann (1906), Fitzgerald (1909), Rochwalier (1909), O'Donoghue (1910–13), Hochstetter (1911), Melissionos (1911), Schütz (1913), LeBlanc (1915), LeCount (1915).

## VEINS OF THE HEAD AND NECK

### VV. ANONYMÆ

Quain (1844) reported an extension well up into the neck on the left, and Cooper (1832) and Gruber (1862) found that it passed through the thymus in about 2 per cent. It is not unusual for these veins to receive the cervical or accessory cervical veins directly. I have encountered, several times, a plexus so complicated that it was impossible to fit it into the usual pattern. It is not unusual for the bronchial veins to be tributaries. They may pass behind the aorta, Daser (1902).

### VV. JUGULARES

I have found the arrangement of the external and anterior jugular veins so variable that I am unable to recognize any special arrangement as anomalous.

The internal jugular may be very small and its function taken over by the more superficial veins. It is occasionally double and may rarely be situated behind the carotid artery. It shows a great variety of tributary connections. Lauth (1815), Cerutti (1819), Otto (1830), Quain (1844), Demarquay (1844), Notta (1847), Luschka (1862), Gruber (1867), Chaquet (1876), Williams (1886), Pinkham (1888), Lunay (1896).

### CEREBRAL SINUSES

Authors do not agree on the development of the sinuses and furnish little assistance in recognizing anomalies. Occasionally one of the sinuses is lacking and a few cases of double sinus have been reported. A wide variety of connections have been encountered, but I have been unable to comprehend any order or basis of classification. The following irregularities have been encoun-

tered: Santorini (1724), Haller (1762), Malacarne (1784), Portal (1803), Vicq d'Azyr (1805), Hallett (1848), Nuhn (1849), Theile (1855), Luschka (1859), Hyrtl (1862), Verga (1856), Trolard (1868), Rüdinger (1876), Langer (1877), Knott (1881), Langer (1884), Sperino (1884), Rüdinger (1888), Dumont (1894), Zander (1892), Callet (1905).

### V. OPHTHALMICA SUPERIOR

The ophthalmic vein may open into the circular sinus or it may establish connections with the cerebral veins. It may have no deep connection, but may open into the frontal or supraorbital vein. A secondary connection with the sagittal sinus may be made. The lachrymal vein may remain independent and open into the cavernous sinus or be connected with the temporal. The ophthalmicomeningeal vein of Hyrtl (1859) is an anastomosis between the ophthalmic and cerebral veins, Sesemann (1869), Gurvitch (1883), Festal (1887).

### V. SUBCLAVIA

The subclavian vein may be higher than normal, Robert (1828), or may pass behind the scalenus anticus muscle. I have twice observed it forming a complete venous circle around the muscle; Luschka speaks of the condition and also of a circle about the clavicle. Such a case is reported by Lewis (1909), who shows that a small vein ventral to the subclavius muscle is present in early development. Irregularities of the tributaries of the subclavian are reported by Hyrtl (1862) and Smith (1894).

The vertebral vein may pass in front of the clavicle, McDowell (1849), and it may be connected with any of the surrounding veins; it may receive the upper intercostal veins as tributaries.

The internal mammary vein may open into the vena cava or the azygos. The two veins may be connected across the sternum in each interspace and the connection with the general system may be lost on one side, so that both have a common trunk of termination.

### V. AXILLARIS

The axillary vein may lie at some distance from the artery, Hallett (1848). I have recorded 6 cases in 120 observations. It

is not infrequently multiple, generally two trunks with frequent interconnections, Kaneko (1896), Picqué (1910). Great latitude must be allowed for normal in the arrangement of the tributaries to the axillary vein.

*Humeral Veins.*—Variations consist chiefly in the number of trunks and the relations of the basilic and cephalic to the axillary tributaries, see Barkow (1868). Berry and Newton (1908) made an extensive study of the superficial veins of the upper limb, but reported nothing which belongs in this review. I have observed instances in which the cephalic vein was wanting, but judging from the literature it does not seem to be a frequent anomaly, Hallett (1848), Stocquart (1892).

### V. AZYGOS

The embryology of these veins has not been worked out for man, but as Evans (1912) has pointed out, there is no doubt but that the posterior cardinal veins are concerned in the formation of these veins. All of the variations I have encountered can be explained by the familiar figures of Hochstetter. A study of 200 bodies showed 26 per cent. anomalies, Soloweilschik (1899) found 22 per cent. Many of these are of a very minor nature. The cross connection of the hemiazygos to the azygos is almost as frequently at the 8th as at the 9th vertebra and in 10 per cent. both are present. In 4 per cent. three connections are maintained. In 12 bodies 4 or more connections are found. In 4 bodies the left spermatic and suprarenal veins joined the accessory hemiazygos, while in 12 per cent. a branch from or all of the left renal opened into this vein, Zumstein (1895). In 4 per cent. the accessory hemiazygos does not join the hemiazygos, but enters the coronary sinus. In 14 cases the right and left systems do not connect, but the left forms a separate system flowing into the left anonyma except in one case which enters a persistent left cava.

Gruber (1864) saw a case in which the azygos opened into the hemiazygos, and this in turn into the right atrium. The azygos may curve from the 4th or 5th vertebra, grooving the lung to enter the superior cava just before it enters the heart.

Wrisberg (1778), Rokitansky (1875), Bouchaud (1862), Chiene (1869), Cleland (1869), Gruber (1870), Collins (1874), Gruber (1880), Allen,

(1881), Nicolai (1887), Sperino (1887), Josselin (1893), Molli (1893), Della Rovere (1897), Dévé (1899), Fischer (1899), Maussert (1899), Sejour (1904), Bluntschli (1905), Dufour (1905).

Other anomalies of the Azygos are: Stark (1835), Bastein (1860), Collins (1873), Morison (1878), Brooks (1885), Humphrey (1885), Martin (1897), Della Rovere (1897), Freyberger (1898), Heller (1908), Anikiew (1909), Holtby (1914), Sabin (1914).

### VENA CAVA INFERIOR

The variations which the inferior vena cava presents may be explained from an embryological standpoint by referring to the data on the rabbit and pig presented by Hochstetter (1887), Lewis (1901), and Davis (1910). Lewis concludes that the adult inferior vena cava is formed from the heart, hepatic vessels, upper part of the subcardinal vein, and lower part of the right cardinal vein; he also considers that the left cardinal vein is represented in the ascending lumbar vein. Hochstetter thinks that this latter is a secondary anastomosis.

The most frequent anomaly consists of the persistence of the portion of the left post-cardinal vein which usually atrophies; a list of such general anomalies will conclude the section. In most of these irregularities where the right subcardinal vein has failed to establish connections with the hepatic the renal vein passes dorsal to the aorta, Cruveilhier (1832), LaGendre (1859), Hochstetter (1893), Kollmann (1893), Kaestner (1900), Dwight (1901), Gladstone (1911), Johnston (1912).

Preaortic anastomosis indicates that the anomalies are confined to the post-renal segments of the post-cardinal veins, Paterson (1900), Gerard (1903), Patten (1909), Fränkel (1910).

Gladstone reports the right ureter passing behind the vena cava, also see Hochstetter (1894).

Occasionally the inferior cava establishes a direct connection with the superior, as in the case of Louber (1901), and more frequently the connection is with the azygos system, Bastein (1859), Bachhammer (1879), Carpentier (1888), Kollmann (1893), Berens (1898), Kaestner (1900), Revell (1902), Patten (1909), Alten (1913), Poynter.

A few cases are recorded in which the left cava persists and the

right drops out without transposition of viscera, Hochstetter (1893), Grimsdale (1894), Wäring (1894), Paterson (1900), Gladstone (1905), Kolisko (1909), Fränkel (1910).

Dwight (1901) classifies the anomalies in six groups:

I. Persistence of both cardinals.
II. Persistence of the right cardinal, normal union of the iliacs.
III. Persistence of the right cardinal, high union of the iliacs.
IV. Persistence of the left cardinal, iliacs normal.
V. Persistence of lower portion of the left cardinal, iliacs normal.
VI. Persistence of the left cardinal, high union of iliacs.

Since many of the descriptions are lacking in detail, I have not attempted to give the references in a classified order.

Wilde (1740), Pohl (1773), Horner (1817), Gurlet (1819), Lobstein (1820), Zagorsky (1822), Herholdt (1828), Bujalsky (1829), Ehbets (1838), Hyrtl (1839), McWhinnie (1840), Paulus (1842), Moser (1848), Leudet (1852), Dorsch (1858), Bastein (1859), Klob (1859), LaGendre (1859), Martin (1826), Zaaijer (1869–72), Gruber (1872–80–82), Flesch (1876), Garibaldi (1876), Bachhammer (1879), Walsham (1880), Geffrier (1881), Kadyi (1881), Antonelli (1882), White (1883), Walter (1884), Nicolai (1886), Hochstetter (1887), Carpentier (1888), Kirschner (1888), Charles (1889), Eppinger (1890), Robinson (1891), Kollmann (1893), Foriep (1894), Grimsdale (1894), Hart-Smith (1894), Pangratz (1894), Waring (1894), Parsons (1895), Zumstein (1895), Brin (1897), Cavasse (1897), Farmer (1897), Gosset (1898), Tichomeroff (1898), Berens (1898), Aimé (1900), Kaestner (1900), Paterson (1900), Dwight (1901), Lauber (1901), Macalister (1901), Taguchi (1901), Revell (1902), Ancel (1903), Gérard (1903–6), Benöhr (1904), Heller (1904), Georg (1906), Chalier (1907), Patten (1909), Angier (1910), Fränkel (1910), Gladstone (1911), Lucas (1916), Mouchet (1911), Givens (1912), Waterston (1912), Alten (1913), Neuberger (1913), Rischbreth (1913), Carriere (1914), Nützel (1914), Gérard (1914).

### VV. SPERMATICA ET RENALES

As pointed out above, these veins often show irregularities when the left inferior vena cava persists. I have seen one case in which the spermatic consisted of a number of intercommunicating trunks, some of which opened into the common iliac, Soemmering (1800). Communication with the vena cava and accessory renal is not un-

usual, Fleischmann (1815), Macalister (1868), Miura (1898), Pensa (1908). Zumstein (1895) found that the right spermatic opened into the right renal 4 times in 220 observations.

Renal veins show some tendency to form two or more trunks as the arteries do, but the frequency of this anomaly is not so great; my series shows a frequency of about 7 per cent. For references on this subject see list under renal arteries above.

### V. PORTÆ

Accessory splenic veins are reported by Blasius (1674), Blancard (1688), Watson (1838), and Hyrtl (1839). The splenic vein may anastomose with the renal, Lejars (1888), Marian (1901), or with the superior mesenteric, Hyrtl (1859).

A connection may exist between the superior and inferior mesenteric veins, Villemin (1912). Tellaux reports finding a superior mesenteric vein opening into the renal vein. A very excellent detailed study of the mesenteric veins in their normal arrangement is given by Descomps (1912).

### V. UMBILICALIS

Luschka recognized a normal connection between the umbilical and deep epigastric veins, but I believe the first description of the embryology was by Burow (1838). This was confirmed by Wertheimer (1886) and Hochstetter (1888). It would seem, however, from pathological conditions that such a normal connection was at least suspected; see Serres (1830), Burow (1838), Russell (1873), Sperino (1879), Brigidi (1888), Beniqué (1905–12). An enlargement of such vessels was noted by Pegot (1833) and Champneys (1872).

Giacomini (1873) saw a connection between the portal and right common iliac.

### VENÆ ILIACÆ

The common iliac vein irregularities are largely associated with the persistence of the left vena cava inferior already presented. They occasionally receive an accessory renal vein or even the complete renal drainage. They may be entirely separated from the normally accompanying artery or may form a vena cometes about it, Quain (1844), Treadwell (1895).

The external iliac may be double, Delitzin (1901), or may lie lateral to the artery, Harrison (1839).

The inferior epigastric vein may be double—I have seen three cases—or may run through the femoral ring, Labatt (1838), or connect with the obturator or pudendal, Dubrueil (1847), Redfern (1850).

*Lower Extremity*

There are few records of anomalies of the veins of the lower extremity and those I have picked up are of such minor character as to hardly claim our interest. A double popliteal has been reported as an anomaly, but Robinseau (1897) found the condition present in 17 of 20 subjects examined; I did not find such a high frequency, 40 per cent., but agree with him that it is not to be classed with anomalies. Certain irregularities, of course, and connections have been mentioned by Quain (1844), Langer (1867), Giovanardi (1879), Davidson (1890), Gruber (1872), Altuchow (1895), Focacci (1904), Dienlafé (1904).

## GENERAL SUMMARY

Certain impressions are gained from a general survey of vascular variations and their literature which seem worth while to include in this study.

Variations are found within certain limits which, in the great majority of cases, exactly correspond to developmental stages and represent either abnormal persistence or atrophy of channels. They are not as variable as Baader's capillary theory would imply, consequently must belong to a later stage of development, or else the early capillaries are precursors of, rather than a stage in, the development of the vascular tree.

Vascular anomalies belong with other teratological conditions and their etiology is probably the same as that of other developmental irregularities.

There seems to be little information of a basic character to be gained from the study and tabulation of these anomalies; however, our interest in them will probably continue because of their infrequency.

There may be a tendency to greater frequency of certain variations in some races than in others, but anthropological studies so far made present no convincing evidence.

In the regions of frequent and wide variation certain studies have attempted to arrange the anomalies in arbitrary classes or types, but this is contrary to the actual condition as shown by careful measurements and is not in accord with our knowledge of development.

Vascular anomalies have been a great stimulus to the study of development and it is hoped that this paper may be helpful in indicating regions where our knowledge is still imperfect.

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# UNIVERSITY STUDIES

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## A SYNOPSIS OF THE TABANIDAE OF NEBRASKA, WITH A DESCRIPTION OF A NEW SPECIES FROM COLORADO

BY EVERETT E. WEHR
UNIVERSITY OF NEBRASKA

Recently, the writer has had occasion to prepare a synopsis of the species of *Tabanidae*, otherwise known as horseflies, deerflies or gadflies, of the State of Nebraska. These flies are of importance to the farmer and stock raiser because of their blood-sucking propensities and their annoyance to stock. They breed in marshy lands and wet soil. This synopsis is based altogether on specimens collected in Nebraska and now actually present in the University of Nebraska collection. It is not probable , therefore, that it is a complete list. More extensive collecting over the state would probably reveal the presence of other species, since very little time has been spent in especially collecting these insects.

The classification of Hine has been followed in the main, but in listing the species those that are closely related have been brought together. The writer is indebted to Professors Myron H. Swenk and R. W. Dawson of the University of Nebraska, who have made possible the preparation of this paper. Acknowledgement should also be made to the works of Professor James S. Hine and Baron C. R. Osten Sacken on the *Tabanidae*, since these have contributed greatly toward the satisfactory identification of the species and the synoptic work.

Only three of the North American genera of *Tabanidae* are represented in the Nebraska fauna, viz., *Silvius, Chrysops* and *Tabanus.* In order to show the relationship of these three genera, however, the following table (after Hine) of the nine North American genera is given:

1. Hind tibiae with spurs at the tip ..... 2

   Hind tibiae without spurs ..... 6

2. Third segment of the antennae composed of eight annuli, the first of which is only a little longer than the following ones ..... 3

   Third segment of the antennae composed of only five annuli, the first of which is much longer than the following ones; ocelli present ..... 5

3. Front of female narrow; ocelli present or absent; fourth posterior cell at least open ..... *Pangonia*

   Front of the female broad with a denuded callus; ocelli present 4

4. Eyes in the female acutely angulated above; wings in both sexes with a dark picture ..... *Goniops*

   Eyes in the female not acutely angulated above; wings hyaline ..... *Apatolestes*

5. Second segment of the antennae about half as long as the first; eyes in life with numerous small dots ..... *Silvius*

   Second segment of the antennae as long or but little shorter than the first; wing with a dark picture ..... *Chrysops*

6. Third segment of the antennae with a well developed basal process ..... *Tabanus*

   Third segment of the antennae without, or with a rudimentary basal process ..... 7

7. All the tibiae enlarged, the hind pair ciliate ..... *Snowiellus*

   None of the tibiae enlarged and the hind tibiae not ciliated ..... 8

8. Front of the female as broad as long, the callus transverse ..... *Haematopota*

   Front of the female narrow ..... *Diachlorus*

**Silvius** Meigen

There are but five known North American species in this genus, one of which is here described as new. Two of these five species are known to occur in Nebraska. In order to show the relationships of the new species, the following key to all five of the North American species is offered:

1. Wings blackish, costa more intense.....*jonesi*

   Wings hyaline, with or without spots..... 2

2. Wings without spots, whole body yellowish..... 3

   Wings usually spotted, whole body grayish..... 4

3. Abdomen uniformly yellow with a dark spot beneath the scutellum and an elongated spot of the same color in the middle of the second segment; denuded areas on face; length ♀, 10-12 mm. ..... *gigantulus*

   Abdomen not uniformly yellow, no denuded areas on face; length ♀, 10-11 mm.....*microcephalus*

4. Abdomen with four longitudinal rows of spots; length ♀ ♂, 6-10 mm.....*quadrivittatus*

   Abdomen with two longitudinal rows of spots; length ♀, 10 mm. ..... *pollinosus*

**Silvius microcephalus** n. sp.

♀. Length 10-11 mm. In coloration this species approaches *gigantulus*, except that it is paler. The head appears small in comparison to the rest of the body, and the abdomen is broad. Face and front grayish-pollinose, sparsely covered with pale yellow and black pile; no denuded areas on face as in *gigantulus*. Front narrow; frontal callosity small, black and round; ocelli ruby-colored; ocelligerous tubercle of the same color as the front. Proboscis shorter than the head. Antennae with first two joints yellow, beset with short black hairs, the basal annulus reddish-yellow, the apical four annuli black. The antennae is but little longer than the proboscis. The thorax is yellowish-pollinose, darker than either the face or the abdomen, with pale and black pile associated together, and with three longitudinal faint mesonotal vittae. Scutellum of the same color as the thorax. Abdomen broadly yellow on the sides, leaving a broad black stripe in the middle on which is a row of small faint gray triangles, the apex of that on the second segment reaching

the posterior margin of the first segment; the venter pale yellow except for a black area in the apex of the second segment; both dorsal and ventral aspects covered with black hairs. Wings hyaline with costa and stigma yellow; a stump on the anterior branch of the third vein. Legs yellow with the last four tarsi dark, the apical half of the tibiae and tarsus heavily beset with black hairs.

*Type.* Ute Creek, Costilla County, Colorado, on sage flats, August 7, 1907 (R. W. Dawson). Two ♀ ♀, type and paratype. University of Nebraska collection. Compared with *gigantulus* ♀ ♀ from Truckee, California, August 4, 1914 (L. Bruner), also in the University of Nebraska collection.

**Silvius quadrivittatus** Say. Jr. Acad. Nat. Sci. Phil., iii, 33 (1823); Compl. Writ., ii, 54 (1859); Hine, Ohio Naturalist, v, No. 2, 229 (1904).

Common over the entire state of Nebraska. One ♂ and eighty-three ♀ ♀ from South Bend, Cass County; Louisville Cass County; Lincoln, Lancaster County; Ashland, Saunders County; South Sioux City, Dakota County; McCook, Redwillow County, Culbertson, Hitchcock County, and Haigler, Dundy County, June 14th to September 3rd.

**Silvius pollinosus** Williston. Tr. Conn. Acad. Sci., iv, 224 (1879).

A ♀ specimen from McCook, Redwillow County, June 20, 1913 (R. W. Dawson), establishes the place of this species in the Nebraska fauna.

### **Chrysops** Meigen

There are specimens of nine species of this genus collected in Nebraska represented in the University of Nebraska collection. Of these, the males of five species are available for study. I offer the following key as an aid in separating the species:

1. Apex of the wing beyond the cross-band hyaline; body uniformly black; thorax on each side with a tuft of yellow hair at root of wings; length ♀, 8-9 mm.....*carbonarius*

Apex of the wing beyond the cross-band not entirely hyaline..... 2

2. First antennal segment distinctly enlarged; the hyaline spot is crescent-shaped and entirely surrounded by the dark of the wing; the first two segments of the abdomen yellow on the sides, length ♀, 7-9 mm., ♂, 7-8 mm. .....*fulvaster*

First antennal segment not distinctly enlarged..... 3

3. A hyaline spot in the discal cell; face grayish with four black dots; length ♀, 9-10 mm., 8-9 mm.....*discalis*

No hyaline spot in the discal cell..... 4

4. First basal cell hyaline..... 5

First basal cell altogether or to a considerable extent infuscated 7

5. Abdomen with a middorsal yellow stripe on the first four segments, which is attenuated posteriorly; length ♀, 7-8 mm. *obsoletus*

Abdomen without a middorsal yellow stripe..... 6

6. A black triangle encroaches upon the posterior part of the yellow on each side of the second abdominal segment; length ♀, 8-11 mm.; ♂, 8-9 mm. .....*moerens*
No black triangle on each side of the second abdominal segment; length ♀, 8 mm., ♂, 7-8 mm.....*callidus*

7. Frontal triangle, thoracic stripes and scutellum yellow; length ♀, 9 mm.; ♂, 7-8 mm. .....*vittatus*

Frontal triangle and scutellum mostly or altogether black..... 8

8. The hyaline triangle crosses the second longitudinal vein, apical spot invades the first posterior cell; length ♀, 8-9 mm.....*sequax*

The hyaline triangle does not cross the second longitudinal vein, and is almost as wide at the apex as at the base of wing; length ♀, 7-8 mm.....*pikei*

**Chrysops carbonarius** Walker. List., i, 203 (1848); Hine, Ohio, Naturalist, v, No. 2, 220 (1904).

1848. *niger* Walker, List., i, 202.
1850. *provocans* Walker, Dipt. Saund., i, 73.
1850. (?) *atra* Macquart, Dipt. Exot. Suppl., iv, 40.
1875. *fugax* Osten Sacken, Prodrome, i, 375; Williston, Trans. Kans. Acad. Sci., x, 132 (1887).

There are in the collection seven ♀ ♀, all collected in Sioux County, chiefly in Monroe and Warbonnet Canyons, June 18th to 27th.

**Chrysops fulvaster** Osten Sacken. West. Dipt., 221 (1877); Hine, Ohio Naturalist, v, No. 2, 223 (1904).
1892. *coloradensis* Bigot (in part), Mem. Soc. Zool. Fr., v, 605.

This is evidently a very comon species in Nebraska, since there are specimens in the collection represented from a large number of localities. Nine ♂ ♂ and thirty-one ♀ ♀ from the following localities: Sowbelly Canyon, Sioux County; Glen, Sioux County; Pine Ridge, Dawes County; Mitchell, Scottsbluff County; Glenn Rock Canyon, Banner County; Halsey, Thomas County; Haigler, Dundy County, and Valentine, Cherry County, June 13th to August 31st.

**Chrysops discalis** Williston. Tr. Conn. Acad. Sci., iv, 245 (1887); Hine, Ohio Naturalist, v, No. 2, 221 (1904).

Eight ♀ ♀ have been taken at the following localities: Haigler, Dundy County; Bridgeport, Morrill County, and Mitchell, Scottsbluff County, June 10th to July 29th. The larger size will serve to separate this species from *fulvaster*, which it somewhat resembles.

**Chrysops obsoletus** Wiedemann. Dipt. Exot., i, 108 (1821); Hine, Lousiana Bull. No. 93, 32 (1907).

Evidently this is not a common species in Nebraska. Only two ♀ ♀ are represented in the University collection, both taken at Omaha, Douglas County, on July 28th and August 11th, respectively.

**Chrysops moerens** Walker. List., i, 201 (1848); Hine, Ohio State Acad. Sci. Special Papers, No. 5, 40 (1903).
1867. *aestuans* Van der Wulp, Tijd. Ent., x, 135, pl. 3, fig. 8 and 9; Osten Sacken, Prodrome, i, 378 (1875).

This species resembles the following species very closely. It is found over the entire state. Two ♂ ♂ and twenty-three ♀ ♀ taken at Omaha, Douglas County; Lincoln, Lancaster County; South Sioux City, Dakota County; Neligh, Antelope County; Bridgeport, Morrill County, and Mitchell, Scottsbluff County, June 21st to August 15th.

**Chrysops callidus** Osten Sacken. Prodrome, i, 379 (1875); Hine, Louisana Bull. No. 93, 28 (1907).

Moderately common in the eastern part of the state. One ♂ and five ♀ ♀ taken at Omaha, Douglas County; Lincoln, Lancaster County; South Sioux City, Dakota County, and Neligh, Antelope County, June 22nd to August 13th.

**Chrysops vittatus** Wiedemann. Dipt. Exot., i, 106 (1821); Hine, Louisana Bull. No. 93, 35 (1907).

1848. *areolatus* Walker, List., i, 197.
1868. *lineatus* Jeannicke, Neue Dipt. Exot., 26.

This species very closely approaches *striatus* of the eastern states. Three ♂ ♂ and six ♀ ♀ have been collected at Omaha, Douglas County, and Lincoln, Lancaster County, from July 15th to August 11th.

**Chrysops sequax** Williston. Tr. Kans. Acad. Sci., x, 133 (1887); Hine, Louisana Bull. No. 93, 34 (1907).

This species presents many variations and consequently is difficult to define. It is likely to be confused with *C. striatus*. Fifteen ♀ ♀ have been collected at the following localities: Carns, Keya Paha County; Halsey, Thomas County, and Haigler, Dundy County, from July 8th to August 19th.

**Chrysops pikei** Whitney. Canad. Ent., xxxvi, 205 (1904); Hine, Louisana Bull. No. 93, 33 (1907).

Only four ♀ ♀ are present in the University collection, and all of these were taken around Lincoln, Lancaster County, from June 28th to August 4th. Evidently it is not a very common species.

**Tabanus** Linnaeus

The thirteen species of this genus known to occur in Nebraska may be separated by the following key:

1. Eyes glabrous ..... 2

   Eyes pilose ..... 9

2. Abdomen with definite white markings..... 3

   Abdomen without definite white markings..... 7

3. Abdomen with a middorsal stripe; a row of gray triangles on either side ..... 4

   Abdomen not so colored ..... 5

4. Eyes with a single band in life; thorax uniformly pollinose; costal cells yellowish; length ♀, 10-14 mm., ♂ 13 mm. .....*costalis*

   Eyes with three bands in life; thorax dark colored with gray stripes; costal cells hyaline; length ♀, 14-16 mm., ♂, 12-14 mm. .....*lineola*

5. Wings with first posterior cell closed.....*abdominalis*

   Wings with first posterior cell open..... 6

6. Prevaling color of abdomen black; segments 3-5 with large gray triangles, segment 2 of female with a rounded white dot on each side, length ♀, 16-19 mm., ♂ 15-16 mm.....*trimaculatus*

   Prevailing color of the abdomen reddish-brown; segment 2 with a gray triangle; length ♀, 18-20 mm., ♂, 19-20 mm.....*sulcifrons*

7. Thorax, in well preserved specimens, densely covered with white pollen; abdomen void of white pubescence..... 8

   Thorax black, abdomen covered with white pubescence; entire body including wings uniformly black; length ♀, 21-25 mm., ♂, 22 mm.....*atratus*

8. Tibiae with white ring at base; length ♀, 18-21 mm.; ♂, 18-19 mm. ..... *punctifer*

   Tibiae without white ring at base; length ♀, 18 mm.....*stygius*

9. Prevailing color of the whole body yellowish; ocelligerous tubercle absent in both sexes; length ♀, 9-10 mm., ♂, 11 mm. .....*bicolor*

Prevailing color of the whole body dark..... 10

10. Abdomen with a wide middorsal brown stripe and a gray stripe of about the same width on either side; length ♀, 12-13 mm., ♂, 13-14 mm.....*dodgei*

Abdomen not so colored..... 11

11. Subcallus denuded in the female; venter of abdomen black, covered with gray pollen; dark species; length ♀, 13-15 mm. .....*rhombicus*

Subcallus not denuded in the female..... 12

12. Wings reddish hyaline, with no distinct fuscous on the margins of the cross-veins and bifuration of the third vein; lateral abdominal triangles usually rounded; length ♀, 13-14 mm. *septentrionalis*

Wings with distinct fuscous on the margins of the cross-veins and bifurcation of third vein; lateral triangles oblique; large large gray species; length ♀, 13-17 mm.....*reinwardtii*

**Tabanus costalis** Wiedemann. Auss. Zweifl. Ins., i, 173 (1828); Hine, Louisana Bull. No. 93, 46 (1907).
1848. *vicarius* Walker, List., i, 187.
1855. *baltimorensis* Marquart, Dipt. Exot., Suppl., 34.

This species is known as the green-headed horse fly or "greenhead." Twelve ♂ ♂ and ten ♀ ♀ taken at the following localities: Lincoln, Lancaster County; South Bend, Cass County; Fremont, Dodge County; South Sioux City, Dakota County; Fairmont, Fillmore County; Haigler, Dundy County, and Harlan County, June 28th to July 31st.

**Tabanus lineola** Fabricius. Ent. Syst., iv, 369 (1775); Hine, Louisana. Bull. 93, 50 (1907).
1848. *simulans* Walker, List., i, 182.
1856. (?) *scutellaris* Walker, Dipt. Saund., 27.
1859. *trilineatus* (Latr?) Bellardi, Saggio Ditt. Mess., i, 63.

This is a very common species over the state. Fifteen ♂ ♂ and twenty-seven ♀ ♀ have been taken at Omaha, Douglas County; Lincoln, Lancaster County; South Bend, Cass County; West Point, Cuming County; Fairmont, Fillmore County;

McCook, Redwillow County, and Mitchell, Scottsbluff County, from June 13th to August 24th.

**Tabanus abdominalis** Fabricius. Syst. Antl., 96 (1775); Hine, Louisana Bull. No. 93, 41 (1907).

Only two ♀ ♀ are represented in the University collection, one of which was taken at Lincoln, Lancaster County, August 6, 1910 (Zimmer) and the other in Harlan County (Hedgcock).

**Tabanus trimaculatus** Palisot de Beauvois. Ins. Dipt., 56, tab. 1, fig. 5 (1805-21); Hine, Louisana Bull. No. 93, 58 (1907).
1834. *quinquelineatus* Macquart, Hist. Nat. Dipt., i, 200.

Two ♂ ♂ and five ♀ ♀ have been taken from the following localities: Lincoln, Lancaster County; South Bend, Cass County; West Point, Cuming County, and Fairmont, Fillmore County, from June 12th to July 16th.

**Tabanus sulcifrons** Macquart. Dipt. Exot., Suppl., v. 33 (1885); Hine, Louisana Bull. No. 93, 56 (1907).
1875. *tectus* Osten Sacken, Prodrome, ii, 436.

This species is very near *exul*. One ♂ and two ♀ ♀ have been taken at Rulo, Richardson County, July 3, 1915 (Partridge), and Lincoln, Lancaster County, July 30, 1909 (Burnham). For a time I believed the ♂ to be *exul*. The abdominal triangles are only of moderate size, but the small facets lie high (nearly in the middle of the head), the pleurae have a tuft of brown hair in the middle, the disc of the discal cell is distinctly less brown than the brownish shadow at the base and along the forth vein, and the abdomen is distinctly roof-shaped.

**Tabanus atratus** Fabricius. Syst. Ent., 789 (1775); Hine, Louisana Bull. No. 93, 44 (1904).
1770-82. *americannus* Drury, Ins., i, tab. 44, fig. 3.
1805-21. *niger* Palisot de Beuvois, Ins. Dipt., tab i, fig. 1.
1828. *validus* Wiedemann. Auss. Zweif. Ins., i, 113.

This is a common species in the eastern part of the state. Four ♂ ♂ and thirteen ♀ ♀ have been collected at the following places: Omaha, Douglas County; Lincoln, Lancaster County; Louisville, Cass County; South Sioux City, Dakota County; Halsey, Thomas County, and Duff, Rock County, from June 16th to September 10th.

**Tabanus punctifer** Osten Sacken. Prodrome, ii, 453 (1875); Hine, Ohio Naturalist, v, No. 2, 242 (1904).

This an extreme western species. There are five ♂ ♂ and twenty-three ♀ ♀ from Monroe Canyon, Warbonnet Canyon and Glen, Sioux County, and Glenn Rock Canyon, Banner County, June 13th to September 2nd.

**Tabanus stygius** Say. Jr. Acad. Sci. Nat. Phil., iii, 33 (1823); Hine, Ohio State Acad. Sci. Special Papers, No. 5, 54 (1903).

There is only one ( ♂ ) specimen represented in the University collection and it was with considerable hesitancy that it has been idenitfied with the above species. This species is very closely related to *nigrescens* and the ♂ ♂ are separated only through great familiarity. As *nigrescens* has never been collected this far west, at least to my knowledge, and the thorax of *nigrescens* is shining black, it was determined as *stygius*. It was collected at Weeping Water, Cass County, July 20th (H. S. Smith).

**Tabanus bicolor** Wiedemann. Dipt. Exot., i, 96 (1821); Hine, Ohio State Acad. Sci. Special Papers, No. 5, 48 (1903).

1848. *fulvescens* Walker, List., i, 171; Osten Sacken, Prodrome, ii, 460 (1875); Catalogue 229.

1855. *ruficeps* Macquart, Dipt. Exot., Suppl., 5, 35.

Only two ♂ ♂ and two ♀ ♀ of this species are represented in the collection. One ♂ and ♀ were collected in Sioux County, one ♂ at McCook, Redwillow County, and one ♀ at Haigler, Dundy County, all western localities. June 20th to August 20th.

**Tabanus dodgei** Whitney. Canad. Ent., xi, 37 (1879); Hine, Ohio Naturalist, v, No. 2, 236 (1904).

The coloration of the abdomen makes this species a distinct one from any known to the writer. There are one ♂ and two ♀ ♀ before me, a pair taken at West Point, Cuming County, and the odd ♀ at Broken Bow, Custer County, June.

**Tabanus rhombicus** Osten Sacken. Prodrome, ii, 472 (1876); West. Dipt., 218 (1877); Hine, Ohio Naturalist, v, No. 2, 242 (1904).

There are several specimens before me that agree with Osten Sacken's second form of *rhombicus*, that is, the lateral triangles on abdominal segments 2-5 are oblique; the intermediate triangles show a tendency to a linear prolongation of the apex toward the next segment; the subcostal cell is nearly hyaline; the subcallus is not denuded; and there is no stump on the anterior branch of the third vein. Hine in "The Tabanidae of Western United States and Canada" makes the statement that he believes Osten Sacken's second form of *rhombicus* to be *centron*. Hine further states that the distinguishing character that separates *rhombicus* from *centron* is the color of the abdomen, it being black and covered with a white pubescence in *rhombicus* and largely red in *centron* The specimens before me have the venter colored as in *rhombicus*.

Eight ♀ ♀ taken at Warbonnet Canyon, Monroe Canyon, Sowbelly Canyon, Sioux County; Mitchell, Scottsbluff County, and Glenn Rock Canyon, Banner County, June 23rd to August 7th.

**Tabanus septentrionalis** Loew. Verh. zool.-bot. Ges., viii, 592 (1858); Hine, Ohio Naturalist, v, No. 2, 243 (1904).

One ♀ taken at Mitchell, Scottsbluff County, August 21st.

**Tabanus reinwardtii** Wiedemann. Auss. Zweifl. Ins., i, 130 (1821) Hine, Ohio State Acad. Sci. Special Papers, No. 5, 54 (1903).
1850. *erthroletus* Walker, Dipt. Saund., 25, tab. 2, fig. 1.

Eleven ♀ ♀ taken at Monroe Canyon and Glen, Sioux County, and Valentine, Cherry County, August 6th to 23rd.

# A SYNOPSIS OF THE SYRPHIDAE OF NEBRASKA WITH DESCRIPTIONS OF NEW SPECIES FROM NEBRASKA AND COLORADO

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In June, 1907, Mr. Paul R. Jones published in the Journal of the New York Entomological Society "A Preliminary List of Nebraska Syrphidae with Descriptions of New Species." At that time there was available only a comparatively small collection of Syrphid flies, but apparently it contained a fairly good representation of the species found in the state. Subsequent collectors have contributed a considerable amount of new material from the state in which there are twelve additional species, two of which are new. With these additions, the Nebraska list is increased to ninety species.

At the present time the classification of the family Syrphidae seems to be undergoing a course of complete revision. Many of the old generic names that had been suppressed for a number of years have been brought into use again, and many of the genera subdivided. Such a course of revision has simplified the synoptic keys and facilitated the determination of doubtful species. It is sincerely hoped that this good work will continue to completion. The author believes that insufficient work on the group as a whole has resulted in the erection of many specific names which are probably not valid.

As a guide to the division of the family *Syrphidae* into subfamilies and genera, the writer has followed the classification recently proposed by Shannon.* This work on the family is the most recent and complete now published. Mention should also be made of Metcalf's paper on "Syrphidae of Ohio" and Williston's "Synopsis of North American Syrphidae," as these

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works have aided materially in making identifications and in preparing the synoptic tables.

To Professors Myron H. Swenk and R. W. Dawson the writer wishes to express his gratitude for the many valuable criticisms and suggestions offered during the preparation of this paper, and also for a critical reading of the manuscript.

## CHARACTERS OF THE FAMILY SYRPHIDAE

Antennae three-jointed; usually with a dorsal arista, rarely with a terminal style; third vein of the wings without an anterior branch; anal cell acute and prolonged nearly to the wing margin; either a spurious vein present between the third and fourth veins, or a subsquamal plumose filament (the plumula) present, usually both present; empodium bristle-like; hypopygium asymmetrical, an elongated mesocoxal projection present on middle coxae.

## TABLE OF SUBFAMILIES OF SYRPHIDAE

1. Chitinous parts of body thickly punctate; prostigma placed on cephalic aspect of thorax, thorax being foreshortened; abdomen of both sexes consisting of four visible segments; arista as short as the width of third antennal joint; spurious vein of anal cell (elsewhere called the anal furrow) very short, not extending as far as anal lobe incision; eyes faintly pubescent. Medium sized flies ..... *Nausigasterinae*

   Body not punctate and otherwise not as above..... 2

2. Antennae very elongate and with a terminal style; anterior cross-vein joining discal cell at or beyond the middle; usually an adventitious branch extending into first posterior cell (discal cell, Shannon) from third vein; face produced downwards, bare; plumula absent; males holoptic, with only four visible abdominal segments; females with five abdominal segments.... *Cerioidinae*

   Antennae without a terminal style, excepting in *Callicera* and *Pelecocera*, but these genera have the anterior cross-vein joining the discal cell well before the middle..... 3

3. Antennae very elongate, with a bare dorsal arista; face evenly

and gently arched, never produced forward at oral margin and entirely clothed with pile; a stigmatical cross-vein present; third vein usually (absent only in *Mixogaster*) with an adventitious and free branch projecting into the first posterior cell (discal cell, Shannon); apical cross-vein upright or recurrent; both sexes with three to four visible abdominal segments exclusive of genitalia; males dichoptic.....*Microdontinae*

Antennae not elongate and possessing dorsal arista, excepting in a few genera, which are without a stigmatical cross-vein, and the apical cross-vein is parallel with the wing margin (*Chrysotoxum* and *Sphecomyia*); or, if the apical cross-vein is upright or recurrent (*Chrysogaster*), then the mouth is produced forward ..... 4

4. The humeral calli and region between them distinctly destitute of pile, the head being "cupped" over the anterior end of thorax, causing the pile to end abruptly behind the posterior margin of humeral region (the head may have to be removed to permit examination); antennae placed well above middle of head; arista usually a little shorter than length of antennae; abdomen of both sexes with five visible segments exclusive of genitalia; anterior cross-vein placed well before middle of discal cell .....*Syrphinae*

Pile extending upon the humeral region, abdomen of males with only four visible segments exclusive of hypopygium, females with five ..... 5

5. Apical cross-vein recurrent at distal end; marginal cell closed; arista with either long or very dense plumosity; face protruding downwards; wings broad; alula very broad; squamae usually very broad; thorax frequently bearing bristles..*Volucellinae*

Apical cross-vein parallel with wing margin, or, if recurrent (*Chrysogaster, Eumerus* and *Merodon*), the arista is bare..... 6

6. Arista long plumose for at least the greater two-thirds of its length; marginal cell open; anterior cross-vein placed near or beyond middle of discal cell; either yellow markings present on abdomen, or with dense pile more or less yellow, except *Pyritis*, which has long dense brownish pile; face protruding downwards, or swollen, or tuberculate; the right prong (or style, Metcalf), of the forceps of the genitalia is longer than the left one and tapers to a sharp point, the left prong developed as an obtuse lobe .....*Sericomyinae*

Arista rarely long plumose for one-half its length or more, in such cases some (certain species of *Eristalis*) may be excluded by the closed marginal cell; others (certain *Chilosia*) can be excluded by the absence of yellow body markings or yellow pile, and by having the anterior cross-vein placed well before middle of discal cell; finally, the prongs of the genitalia are similar..... 7

7. Very large yellow and black species; the post stigma very elongate, being very nearly twice as long as broad; marginal cell closed; third vein with a downward loop into first posterior cell (discal cell, Shannon); sixth vein recurrent beyond anal cell; shape of head, position of antennae and length of arista similar to the *Xylota* type, but the face is broadly covered with loose pile (*Milesia* only) .....*Milesinae*

Length of post stigma one and one-half times or less that of width, and otherwise without above combination of characters.... 8

8. Third longitudinal vein with a deep downward loop into first posterior cell (discal cell, Shannon); face except for a medium stripe, clothed with long pile; sixth vein entering margin of wing or short distance beyond anal cell, *i. e.*, usual distance; thorax never bearing bristles; marginal cell closed in *Eristalis* and *Meromacrus*.....*Eristalinae*

Third longitudinal vein usually straight, but in such cases where i tis looped downwards (*Pterallastes* and *Teuchocnemis*) the face is bare, except for a few hairs along eye margins, and sixth vein is prolonged well forward beyond anal cell. (The bare face also excludes *Tropidia* and *Syritta* from *Eristalinae*, while the bristles on the thorax and the brassy color excludes *Chrysochlamys* ..... 9

9. Anterior cross-vein placed well before middle of discal cell; third vein always straight; antennae sometimes with terminal style (*Callicera* and *Pelecocera*).....*Chilosinae*

Anterior cross-vein joining discal cell at or beyond middle; face rarely covered with pile and in such cases third vein is always straight .....*Xylotinae*

### Syphinae

#### KEY TO THE TRIBES

1. Face black, scutellum entirely aeneous or black.....*Melanostomini*

2. Face partly or wholly yellow, scutellum yellow, partly yellow or black (certain species of *Paragus*) ..... *Syrphini*

### Melanostomini

KEY TO THE GENERA

1. Wings shorter than abdomen; abdomen depressed, long-elliptical; front and middle tarsi elaborately developed; vertical triangle large and prominent ..... *Pyrophaena*

   Wings longer than the abdomen ..... 2

2. Front tibiae slender in both sexes ..... *Melanostoma*

   Front tibiae and tarsi of male dilated; those of female slightly widened ..... *Platychirus*

#### **Pyrophaena** Schiner

Only one Nebraska species of this genus.

**Pyrophaena ocymi** (Fabricius). Syst. Ent., iv, 309 (1775); Schiner, Fauna Austr., i, 297 (1862).

A ♂ from Halsey, Thomas County, June 19, 1912 (J. T. Zimmer).

#### **Melanostoma** Schiner

KEY TO THE SPECIES

1. Tubercle of face not at all prominent, indistinct; spots on abdomen quadrate (♂), oval (♀) and yellow ..... *mellinum*

   Tubercle of face prominent, distinct; abdomen bluish green, metallic with inverted wine glass velvety-black opaque areas on third and fourth segments, the handle of the glass reaching the anterior margin of the segment ..... *concinnum*

**Melanostoma melinum** (Linnaeus). Syst. Nat., 10th ed., 594 (1758). 1858. *scalaris* Osten Sacken, Cat. Dipt., 121.

Two ♀ ♀ are represented in the University collection, and both were taken at Glen, Sioux County, on August 8 and 9, 1905, respectively.

**Melanostoma concinnum** Snow. Kans. Univ. Quart., iii, 229 (1895).

One ♂ taken at Monroe Canyon, Sioux County, on August 9, 1908 (L. Bruner). Prior to this the species had been recorded only from New Mexico and Colorado.

**Platychirus** St. Fargeau and Serville

KEY TO THE SPECIES

1. Front tibiae of the male, on the inner side toward the end, somewhat concave, the outer angle produced into a lappet-like process, yellow spots on abdomen in both sexes very large, leaving only a median stripe and cross-bands; hind femora and tibiae yellow ..... *quadratus*

   Front tibiae of the male gently and evenly convex on the inner side, the top on the outer side less produced, more angular; spots of abdomen smaller; hind legs chiefly black..... 2

2. Front femora in the male with a row of five to seven long bristly hairs; second abdominal segment with large, the fifth with small, yellow spots..... *chaetopodus*

   Front femora without such bristles; second segment of the abdomen in both sexes with a small rounded spot on each side, fifth segment in the male without yellow..... *hyperboreus*

**Platychirus quadratus** (Say.) Jr. Acad. Nat. Sci. Phil., iii, 90 (1823); Osten Sacken, Cat. Dipt., 122 (1858).

This species has a wide distribution in the state. Thirty-one ♂ ♂ and thirty-four ♀ ♀ have been collected from the following localities: Glen, Sioux County; Mitchell, Scottsbluff County; Neligh, Antelope County; Maskell, Dixon County; Lincoln, Lancaster County, and Omaha, Douglas County, between May 9th and September 3rd.

**Platychirus chaetopodus** Williston. Synop. N. A. Syrph., 59 (1886); Snow, Kans. Univ. Quart., iii, 23 (1895).

Five ♂ ♂ and one ♀ from Lincoln, Lancaster County, and Sioux County.

**Platychirus hyperboreus.** (Staeger.) Groenl. Antl., 362 (1845); Willis-

ton, Synop. N. A. Syrph., 29 (1886); Snow, Kans. Univ. Quart., iii, 231 (1895).

A ♂ and ♀ from Lincoln, Lancaster County, April 20th and 25th, 1908 (C. H. Gable).

### Syrphini

#### Key to the Genera

1. Abdomen elongate-slender and contracted beyond the base....*Baccha*

   Abdomen not narrowed on basal portion..... 2

2. Dorsum of thorax with yellow lateral stripes..... 3

   Dorsum of thorax without yellow lateral stripes..... 8

3. Antennae very elongate, about six times as long as broad..... *Chrysotoxum*

   Antennae less than three times as long as broad..... 4

4. Dorsum of thorax with a median cinereous line..... 5

   Dorsum of thorax without such line..... 6

5. Hind femora of male thickened and arcuate, tibiae arcuate and dilated at tip, hind femora of female posteriorly with blackened ring .....*Toxomerus*

   Hind femora and tibiae of male normal, hind tibiae of female entirely yellow, rarely (var. *boscii*) with blackened ring posteriorly ..... *Mesogramma*

6. Eyes of male with an area of enlarged facets above; fourth segment of abdomen with two median yellow stripes and an oblique side spot .....*Allograpta*

   Eyes of male not with an area of enlarged facets above; fourth abdominal segment not so marked..... 7

7. Face projecting below; slender species.....*Sphaerophoria*

   Face receding below; abdomen broadly oval.....*Xanthogramma*

8. Third longitudinal vein deeply constricted into first posterior cell .....*Didea*

   Third longitudinal vein straight or with a gentle downward curve ..... 9

9. Sixth abdominal segment (hypopygium) of male as long as the two preceding ones together, cylindrical; fifth segment of female one-half as long as preceding.....*Eupeodes*

   Sixth segment not peculiar; the fifth segment in the female not over one-half as long as the preceding..... 10

10. Small, robust species; abdomen without yellow stripes.....*Paragus*

    Large species; abdomen with yellow stripes..... 11

11. Front very convex, eyes of male with an area of enlarged facets above (*Lasiopthicus, Catabomba*).....*Scaeva*

    Front normal, eyes of male not with an area of enlarged facets above .....*Syrphus*

**Baccha** Fabricius

KEY TO THE SPECIES

1. Third joint of the antennae elongate oval, obtusely pointed; face very prominent; abdomen more spatula-like.....*clavata*

   Third joint oval, obtusely rounded; face not prominent..... 2

2. Wings almost entirely black, a triangular hyaline spot behind the outer end of the third vein, the auxillary portion more or less subhyaline .....*fuscipennis*

   Wings almost entirely hyaline, a quadrangular fuscous area extending across the middle of the wing from the costa to the fifth longitudinal vein .....*lemur*

**Baccha clavata** (Fabricius). Ent. Syst., iv, 298 (1775); Williston, Trans. Amer. Ent. Soc., xv, 270 (1888).

1886. *Babista* Walker, List., iii, 549 (1849); Williston, Synop. N. A. Syrph., 117.

A ♂ from Lincoln, Lancaster County, in September.

**Baccha fuscipennis** Say. Jr. Acad. Nat. Sci. Phil., iii, 100 (1823); Williston, Synop. N. A. Syrph., 119 (1886).

Four ♂ ♂ and three ♀ ♀ taken at Omaha, Douglas County, between August 15 and September 2, 1913 (L. T. Williams).

**Baccha lemur** Osten Sacken. West. Dipt., 331 (1877); Williston, Synop. N. A. Syrph., 121 (1886); Hunter, Canad. Ent., xxix, 131 (1897).

A ♂ from Monroe Canyon, Sioux County, in August (C. H. Gable).

**Chrysotoxum** Meigen

KEY TO THE SPECIES

1. Lateral margin of third abdominal segment yellow; second and third abdominal bands narrowly interrupted.....*laterale*

   Lateral margin of third abdominal segment not entirely yellow 2

2. Anterior coxae with a yellow spot above..... 3

   Anterior coxae without a yellow spot above.....*pubescens*

3. Black spot of the fifth abdominal segment wine-glass shaped *currani*

   Black spot of the fifth abdominal segment andiron-shaped *cuneatum*

**Chrysotoxum laterale** Loew. Cent., v, 42 (1864); Williston, Synop. N. A. Syrph., 14 (1886); Townsend, Trans. Amer. Ent. Soc., xxii, 35 (1895).

Six ♂ ♂ from Lincoln, Lancaster County, and West Point, Cuming County, June 2nd to June 20th.

**Chrysotoxum pubescens** Loew. Wien. Ent. Monatsch., iv, 84 (1869); Williston, Synop. N. A. Syrph., 15 (1886); Townsend, Trans. Amer. Ent. Soc., xxii, 35 (1895); Hunter, Canad. Ent., xxviii, 91 (1896).

Two ♂ ♂ taken at Lincoln, June 1st.

**Chrysotoxum currani** n. sp.

♀. Length 13 mm. Eyes pilose. Face yellow with a rather broad, fusiform, black stripe extending from the oral margin to the base of the antennae, light pilose. Cheeks yellow, separated from the face by a brownish black stripe extending from the rim of the compound eyes to the oral margin. Front shining black, with a large yellow pollinose

spot on each side. Vertex shining black, black pilose. (Antennae missing.)

Thorax shining metallic black, with yellow lateral stripes. Dorsum with two cinerous stripes, evanescent on the posterior two-fifths. Pleura colored like the dorsum with yellow spots as follows: One above the anterior coxa, one each on the mesopleura, sternopleura, and hypopleura. Scutellum yellow, the disk black fasciolate.

Abdomen shining black, with maize yellow bands. The bands are moderately wide, arcuate and interrupted medially. Segments with apical margins banded buff-yellow, the band on the second segment slightly dilated medially, that on the third segment more strongly so and that on the fourth segment considerably dilated, the yellow of the posterior margin of the fifth segment produced into a triangular spot, so that between this spot and the broad maize yellow fasciae the black forms an inverted wine-glass shaped spot. Venter of the first segment maize yellow, second with posterio-lateral spots maize yellow, third and fourth with anterio-lateral and posterio-lateral spots maize yellow, fifth black.

Coxae and trochanters piceous, femora maize yellow except for an apical reddish yellow band, tibiae maize yellowish, tarsi reddish yellow.

Wings smoky hyaline; base, costal and subcostal cells, proximal parts of first basal and marginal cells lutescent.

*Type.* Lincoln, Lancaster County, Nebraska, June 26, 1908 (C. H. Gable). One ♀. University of Nebraska collection. This species was determined as new by Mr. C. Howard Curran of the Canadian Department of Agriculture, Division of Entomology, who returned it undescribed. In recognition of Mr. Curran's courtesy and valuable contributions on the *Syrphidae,* this species has been named in his honor.

**Chrysotoxum cuneatum** n. sp.

♀. Length 12.5 mm. Antennae black, 2 mm. in length, the lengths of the joints in the ratio of 9:12:15, numbering from the first. Face yellow with a rather broad, fusiform, black stripe, extending from the oral margin to the base of the antennae, light pilose; cheeks luteous, separated from the face by a brownish black stripe. Front shining black, with a yellow pollinose spot on each side, light pilose. Vertex black. Eyes pilose. Occiput covered with ash-gray pollen and with pale yellow pubescence.

Thorax shining bluish black, with lateral yellow stripes. Dorsum with two yellowish pollinose stripes evanescent on the posterior two-fifths. Pleura colored like the dorsum with light buff spots as follows:

One above the anterior coxa, one in front of wing, one each on the mesopleura, sternopleura, and hypopleura. Halteres reddish-yellow. Scutellum yellow, the disk black fasciolate.

Abdomen shining black with faint metallic iridescence, maize yellow banded, the fasciae moderately wide, arcuate, and interrupted medially. The fasciae on the third, fourth and fifth segments wider than the corresponding ones on *currani*. Segments with apical margins banded buff, the bands somewhat narrowed and interrupted in the mid-lateral region on the second and third segments, the anterior margin of the band of the second segment notched at the middle, the buff-yellow posterior margin of the fifth segment produced into a triangular spot, so that between this spot and the broad maize-colored fasciae the black forms an andiron-shaped spot. The shape of this spot is very similar to that of *luteopilosa* Curran, except that the arms are slightly more sinuate. Venter with the first segment maize yellow, the second with the posterio-lateral margins maize yellow, the third and fourth each with an anterior oblique spot and the posterio-lateral margins maize yellow, the fifth with an anterior spot only maize yellow, the spots largest on the third segment and smallest on the fifth.

Coxae and trochanters piceous, femora auburn, tibae maize yellowish, tarsi slightly darker, claws black apically.

Wings smoky hyaline; base, costal and subcostal-cells, proximal parts of first basal and marginal cells lutescent.

*Type*. West Point, Cuming County, Nebraska, June. One ♀. University of Nebraska collection. This species was determined as new by Mr. C. Howard Curran of the Canadian Department of Agriculture, Division of Entomology, who returned it undescribed.

**Toxomerus** Macquart

**Toxomerus geminatus.** (Say). Jr. Acad. Nat. Sci. Phil., iii, 92, 7; Compl. Writ., ii, 80 (1883); Williston, Proc. Amer. Phil., Soc., xx, 310 (1882).

1886. *Mesograpta geminata* Williston, Synop. N. A. Syrph., 102.

West Point, Cuming County; Lincoln, Lancaster County, and Omaha, Douglas County, between June 25th and August 20th; five ♂♂ and two ♀♀.

**Mesogramma** Loew

KEY TO THE SPECIES

1. Scutellum yellow, legs yellow, except the hind tarsi..... 2

   Scutellum black or brown with a yellow border; front of female above only a little narrowed; hind femora wholly yellow..... .....*marginata var.*

2. Front of female only a little narrowed above; third to fifth abdominal segments with narrow lateral yellow margins.....*marginata*

   Front of female much narrowed above; third to fifth abdominal segments with no yellow on the margins.....*polita*

**Mesogramma marginata** (Say). Jr. Acad. Nat. Sci. Phil., ii, 92 (1823).

1886. *Mesograpta marginata* Williston, Synop. N. A. Syrph., 100.

The University collection contains a large series of this species, fifty-four ♂ ♂ and sixty-one ♀ ♀, from the following localities: Rulo, Richardson County; Omaha, Douglas County; Lincoln, Lancaster County; Beatrice, Gage County; Fairmont, Fillmore County; York, York County; South Bend, Cass County; West Point, Cuming County; Coburn, Dakota County; Concord, Dixon County; Maskell, Dixon County; South Sioux City, Dakota County; Neligh, Antelope County; Butte, Boyd County; Carns, Keyapaha County; Glen, Sioux County; Monroe Canyon, Sioux County, and Mitchell, Scottbluff County, between May 9th and September 13th.

**Mesogramma polita** (Say). Jr. Acad. Nat. Sci. Phil., iii, 68 (1823); Snow.

1886, *Mesograpta polita* Williston, Synop. N. A. Syrph., 98. Kans. Univ. Quart., iii, 239 (1895).

Three ♂ ♂ and one ♀ taken at Lincoln, Lancaster County, in the month of September.

**Allograpta** Osten Sacken

**Allograpta obliqua** (Say). Jr. Acad. Nat. Sci. Phil., iii, 89 (1823); Williston, Synop. N. A. Syrph., 96 (1886).

This species has a wide distribution over the state. Twenty-seven ♂ ♂ and twenty-three ♀ ♀ have been taken at Rulo, Richardson County; Omaha, Douglas County; Meadow, Sarpy County; Weeping Water, Cass County; South Bend, Cass County; Lincoln, Lancaster County; York, York County; South Sioux City, Dakota County; Concord, Dixon County; Broken Bow, Custer County; Glen, Sioux County; Monroe Canyon, Sioux County, and Mitchell, Scottsbluff County, beteween May 8th and August 25th.

**Sphaerophoria** St. Fargeaux and Serville

KEY TO THE SPECIES

1. Lateral thoracic stripe ending at the suture; face entirely yellow; abdominal bands beyond the second segment present in the female, usually obsolete or wanting in the male; length 8 mm. ..... *cylindrica*

   Lateral thoracic stripes continuous..... *scripta*

**Sphaerophoria cylindrica** (Say.) Amer. Ent., 1 (1824); Williston, Synop. N. A. Syrph., 105 (1886).

Twenty-nine ♂ ♂ and twelve ♀ ♀ collected at the following localities: Omaha, Douglas County; Bellevue, Sarpy County; South Bend, Cass County; Lincoln, Lancaster County; Fairmont, Fillmore County; South Sioux City, Dakota County; Concord, Dixon County; West Point, Cuming County; Carns, Keyapaha County; Glen, Sioux County; Monroe Canyon, Sioux County; Harrison, Sioux County, and Mitchell, Scottsbluff County, between May 9th and August 31st.

**Sphaerophoria scripta** (Linnaeus). Fauna Suec., ended., 449 (1746); Williston, Synop. N. A. Syrph., 107 (1886).

Three ♂ ♂ and two ♀ ♀ taken at Brock, Nemaha County, and Lincoln, Lancaster County. The ♂ from Brock and two ♀ ♀ from Ute Creek, Colorado, have the coxae and the base of the femora black; this is probably only geographical variation.

**Xanthogramma** Schiner

KEY TO THE SPECIES

1. Scutellum with basal half black.....*flavipes*

   Scutellum yellow ..... 2

2. The yellow band on the second abdominal segment does not attain the lateral margin.....*felix*

   The yellow band on the second abdominal segment attains the lateral margin..... 3

3. Second and third abdominal segments with the extreme anterior angles yellow .....*emarginata*

   Second and third abdominal segments with the extreme anterior angles not yellow.....*aenea*

**Xanthogramma flavipes** (Loew). Cent., iv, 83 (1863); Williston, Synop. N. A. Syrph., 94 (1886).

Two ♂ ♂ taken at Omaha, Douglas County, on July 17 and August 3, 1913, and one ♀ taken on August 17, 1914, by L. T. Williams.

**Xanthogramma felix** Osten Sacken. Bull. Buff. Soc. Nat. Sci., iii, 67 (1875); Williston, Proc. Amer. Phil. Soc., xx, 311, (1882).

A ♂ taken at Lincoln, Lancaster County, July 9, 1909 (C. H. Gable).

**Xanthogramma emarginata** (Say). Jr. Acad. Nat. Sci. Phil., iii, 91 (1823); Williston, Synop. N. A. Syrph., 93 (1886).

Three ♂ ♂ and two ♀ ♀ collected at the following localities: Omaha, Douglas County; West Point, Cuming County, and Neligh, Antelope County, between June 18th and August 30th.

**Xanthogramma aenea** Jones. Jr. N. Y. Ent. Soc., xv, 93 (1907).

The type was a ♀ from West Point, Cuming County, Nebraska, taken in June, 1906, by P. R. Jones. A ♂ collected

at Omaha, Douglas County, August 26th, by L. T. Williams, is in the collection.

### **Didea** Macquart

**Didea fasciata** var. **fuscipes** Loew. Cent., iv, 82 (1863); Osten Sacken, Cat. Dipt., 245, note 212 (1858); Williston, Synop. N. A. Syrph., 89 (1886).

One ♂ and three ♀ ♀ taken at Harrison, Sioux County; Monroe Cayon, Sioux County, and Omaha, Douglas County, between June 1st and August 15th.

### **Eupoedes** Osten Sacken

**Eupoedes volucris** Osten Sacken. West. Dipt., 329 (1877); Williston, Synop. N. A. Syrph., 65 (1886); Snow, Kans. Univ. Quart., iii, 232 (1895).

This species is a very common one in the state. Specimens have been collected at Monroe Canyon, Sioux County; Harrison, Sioux County; Glen, Sioux County; Crawford, Dawes County; Mitchell, Scottsbluff County; Sidney, Cheyenne County; Loup City, Sherman County, and Lincoln, Lancaster County, between May 12th and September 1st.

### **Paragus Latrielle**

KEY TO THE SPECIES

1. Scutellum with a yellow border; face of male without a black median stripe; front of female narrow above.....*bicolor*

   Scutellum without a yellow border; face in both sexes with a black median stripe; front in female of nearly equal width..... 2

2. Abdomen with more or less red on the dorsum..... 3

   Abdomen wholly greenish black.....*angustifrons*

3. Vertical triangle in male large.....*tibialis*

   Vertical triangle in male not unusually large.....*dimidiatus*

**Paragus bicolor** (Fabricius). Ent. Syst., iv, 297 (1794), Williston, Synop. N. A. Syrph., 18 (1886).

Ten ♂ ♂ and five ♀ ♀ taken at Omaha, Douglas County; Cedar Bluffs, Saunders County; Lincoln, Lancaster County; West Point, Cuming County; Carns, Keyapaha County; Halsey, Thomas County; Crawford, Dawes County; Glen, Sioux County, and Monroe Canyon, Sioux County, between April 31st and September 12th.

**Paragus angustifrons** Loew. Cent., iv, 64 (1863); Williston, Synop. N. A. Syrph., 17 (1886).

Two ♀ ♀ from Roca, Lancaster County and Omaha, Douglas County on April 29, 1905 and August 16, 1913, respectively.

**Paragus tibialis** (Fallen). Dipt. Suec. Syrph., 60, 5 (1814-17); Williston, Synop. N. A. Syrph., 19 (1886).

Sixteen ♂ ♂ and three ♀ ♀ collected at the following localities: Omaha, Douglas County; South Bend, Cass County; Lincoln, Lancaster County; Cedar Bluffs, Saunders County; Carns, Keyapaha County; Halsey, Thomas County; Mitchell, Scottsbluff County, and Harrison, Sioux County, between April 31st and September 1st.

**Paragus dimidiatus** Loew. Cent., iv, 63 (1863); Williston, Synop. N. A. Syrph., 20 (1886).

A ♂ taken at Lincoln, Lancaster County, on August 2, 1910 (F. A. Burnham).

**Scaeva** Fabricius

**Scaeva pyrastri** (Linnaeus). Syst. Nat., 10th ed., 594 (1758).

1886. *Catabomba pyrastri* Williston, Synop. N. A. Syrph., 63.

1905. *Lasiophthicus pyrastri* Aldrich, Cat. N. A. Diptera, 363.

Two ♂ ♂ and one ♀ taken in Sioux County, and at Lincoln, Lancaster County, in May, July and August.

**Syrphus** Fabricus.

KEY TO THE SPECIES

1. The three principal bands entire; the second and third ones not reaching the lateral margin, face with a brown stripe.....*americanus*

   The three principal bands interrupted..... 2

   First cross band interrupted; the others entire..... 5

2. Abdominal spots of the third and fourth segments distinctly arcuated ..... 3

   Abdominal spots straight and transverse..... 4

3. Abdominal spots of second and third segments truncate near anterior margin; eyes pilose.....*creper*

   Abdominal spots of second and third segments rounded near anterior margin; eyes bare.....*arcuatus*

4. Fifth abdominal segment, at least, entirely red.....*snowi*

   Fifth abdominal segment not red.....*mentalis*

5. Eyes pilose, not pubescent.....*creper*

   Eyes bare ..... 6

6. Abdominal spots of the second segment reaching the lateral margin ..... 7

   Abdominal spots of the second segment not reaching the lateral margin ..... 10

7. Eyes pubescent.....*torvus*

   Eyes bare ..... 8

8. The cross-bands of the third and fourth segments reach the lateral margin .....*ribesii*

   The cross-bands of the third and fourth segments do not reach the lateral margin..... 9

9. Fifth abdominal segment, at least, red.....*snowi*

   Fifth abdominal segment not red.....*opinator*

10. Face with a brown stripe.....*americanus*

    Face without brown stripe.....*snowi*

**Syrphus americanus** Wiedemann. Auss. Zweifl. Ins., ii, 129 (1830); Osten Sacken, Proc. Bost. Soc. Nat. Hist., xvii, 145 (1875); Williston, Synop, N. A. Syrph., 82 (1886).

This species has quite a wide distribution over the state. Fourteen ♂ ♂ and twenty-six ♀ ♀ have been taken at Falls City, Richardson County; Omaha, Douglas County; Bellevue, Sarpy County; South Bend, Cass County; Lincoln, Lancaster County; South Sioux City, Dakota County; West Point, Cuming County; Neligh, Antelope County, and Monroe Canyon, Sioux County, between April 18th and August 30th.

**Syrphus arcuatus** (Fallen) Dipt Suec. Syrph., 42, 11 (1816); Osten Sacken, Proc. Bost. Soc. Nat. Hist., xviii, 149 (1875).
1877. *lapponicus* Osten Sacken, West Dipt., 326.

Four ♂ ♂ and four ♀ ♀ collected from Monroe Canyon, Sioux County; Glen, Sioux County; Crawford, Dawes County, and Mitchell, Scottsbluff County, between June 10th and August 20th.

**Syrphus mentalis** Williston. Synop. N. A. Syrph., 72 (1886); Hunter, Canad. Ent., xxix, 130 (1897).

One ♂ taken at Glen, Sioux County, on August 10, 1905.

**Syrphus creper** Snow. Kans. Univ. Quart., iii, 234 (1895).

One ♂ taken in May in Sioux County. The second and third abdominal crossbands are narrowly interrupted in this specimen, but in three ♂ ♂ from Colorado (Estes Park, Russell, Ute Creek) they are entire.

**Syrphus torvus** Osten Sacken. Proc. Bost. Soc. Nat. Hist., xviii, 139 (1875); Williston, Synop. N. A. Syrph., 79 (1886).

One ♀ taken at Monroe Canyon, Sioux County, August 16, 1912 (E. J. Taylor).

**Syrphus ribesii** (Linnaeus). Syst. Nat., 10th ed., 593 (1758); Williston, Synop. N. A. Syrph., 77 (1886).

This is an abundant species in the state. There are in the University collection eighteen ♂ ♂ and twenty-one ♀ ♀ from the following localities: Omaha, Douglas County; Child's Point, Sarpy County; Bellevue, Sarpy County; Meadow, Sarpy County; Roca, Lancaster County; Lincoln, Lancaster County; Beatrice, Gage County; Gordon, Sheridan County; Bridgeport, Morrill County; Glen, Sioux County; Harrison, Sioux County; Monroe Canyon, Sioux County, and Bad Lands, Sioux County, between April 10th and September 2nd.

**Syrphus opinator** Osten Sacken. West. Dipt., 327 (1877); Williston, Synop. N. A. Syrph., 83 (1886); Snow, Kans. Univ. Quart., iii, 236 (1895).

Two ♂ ♂ and four ♀ ♀ taken at Monroe Canyon, Sioux County; Glen, Sioux County, and Omaha, Douglas County, between August 7th and 20th.

**Syrphus snowi** Curran. (=**ruficauda** Snow).

1892. *ruficauda* Snow, Kans. Univ. Quart., i, 36.

A ♀ from Monroe Canyon, Sioux County, August 16, 1912 (E. J. Taylor).

### Microdontinae

### **Microdon** Meigen

KEY TO THE SPECIES

1. Slender, elongate species; antennae short, third joint a little longer than the first two together, wings indistinctly fasciate ..... *coarctatus*

   Short, thick-set species..... 2

2. Scutellum not emarginate; large black species; first joint a trifle longer than the second and third together, third joint when viewed from the side lanceolate..... *lanceolatus*

   Scutellum emarginate ..... 3

3. Hind metatarsi extraordinarily thickened and dilated..... *fuscipennis*

Hind metatarsi not extraordinarily thickened or dilated.....*tristis*

**Microdon coarctatus** Loew. Cent., v, 47 (1864); Williston. Synop. N A. Syrph., 6 (1886).

Three ♂ ♂ and one ♀ from Sioux County, the latter specimen collected July 1, 1911 (R. W. Dawson).

**Microdon lanceolatus** Adams. Kans. Univ. Sci. Bull., ii, 212 (1903).

A ♀ taken at Warbonnet Canyon, Sioux County, in 1901 (M. A. Carriker).

**Microdon fuscipennis** (Macquart). Hist. Nat. Dipt., i, 488 (1834); Williston, Synop. N. A. Syrph., 4 (1886).

A ♀ taken at Neligh( Antelope County, June 22, 1909 (W. Thompson).

**Microdon tristis** Loew. Cent., v, 45 (1864); Williston, Synop. N. A. Syrph., 6 (1886).

One ♂ and one ♀ from West Point, Cuming County, June 27, 1906 (P. R. Jones) and Halsey, Thomas County, June 1, 1906 (L Bruner).

### Chilosinae

KEY TO THE GENERA

1. Face entirely black..... 2

   Face more or less yellow..... 10

2. Oral opening broadly oval and without indentations; face very gently and evenly convexed, completely covered with rather long, loose pile..... 3

   Oral opening irregular in outline, having a dorsal directed indentation at the front margin..... 6

3. Face considerably broader at the oral margin than at the antennae (if doubtful, compare *Heringia*).....*Pipiza*

   Face but little or not at all broader at the oral margin than at

the antennae ..... 4

4. Arista microscopically bare; eyes often with a horizontal bare stripe ..... *Pipizella*

   Arista microscopically pilose to the end; eyes always evenly pilose ..... 5

5. Venter of fourth segment in the male only half as long as its dorsum; middle tibiae in female slender; third antennal joint in female elongate..... *Heringia*

   Venter of fourth segment three-fourths as long as its dorsum; middle tibiae in female rounded in front, in male produced anteriorly; trochanters in male usually with long process *Cnemodon*

6. Face and front usually with transverse wrinkles; smaller species ..... *Chrysogaster*

   Face and front not with transverse wrinkles; larger species..... 7

7. Petiole beyond union of third and fourth longitudinal veins much longer than anterior cross-vein..... 8

   Petiole shorter..... 9

8. Eyes hairy; antennal pits separated..... *Chilosia*

   Eyes bare; antennal pits confluent..... *Cartosyrphus*

9. Scutellum unusually large, nearly quadrate; males dichoptic; face concave ..... *Chalcomyia*

   Scutellum normal; males holoptic; face concave in the females, tuberculate in males..... *Myiolepta*

10. Epistoma produced into a long porrect snout; costal vein continued well beyond apex of wing; the usual hairs on the base of the costa reduced to minute spines..... *Rhingia*

    Epistoma not produced snout-like..... 11

11. Arista shorter than antennae; epistoma produced downwards; face in profile gently concave..... *Neoascia*

    Arista longer than antennae; epistoma produced anteriorly; face in profile deeply concave..... *Sphegina*

**Cnemodon** Egger

KEY TO THE SPECIES

1. Wings purely hyaline, last section of fourth vein sinuous....*sinuosa*

   Wings cinereous or brownish hyaline, last section of fifth vein bent at its middle; third antennal joint black above; male with middle and hind coxae with processes.....*calcarata*

**Cnemodon sinuosa** Curran. Proc. Cal. Acad. Sci., xi, No. 16, p. 368 (1921).

A ♀ from Glen, Sioux County, 9,000 feet, August 18, 1906 (P. R. Jones). This specimen agrees pretty closely with *sinuosa* but has been given that name tentatively only, because males are necessary for the certain determination of it.

**Cnemodon calcarata** (Loew). Cent., vi, 42 (1865).
1886. *Pipiza calcarata* Williston, Synop. N. A. Syrph., 24.
One ♂ from Lincoln, Lancaster County, in April.

**Pipiza** Fallen

**Pipiza femoralis** Loew. Cent., vi, 38 (1865); Williston, Synop. N. A. Syrph., 26 (1886).

Two ♂ ♂ and three ♀ ♀ from Roca and Lincoln, both in Lancaster County, May and June.

**Pipizella** Rondani

**Pipizella pulchella** (Williston). Synop. N. A. Syrph., 29 (1886); Curran, Proc. Cal. Acad. Sci., xi, No. 16, p. 349 (1921).

A ♂ from Glen, Sioux County, August 20, 1906 (H. S. Smith). The third joint of the antenna is not as long as that of specimens from Colorado, but the last section of the fourth vein is bent near its middle.

**Heringia** Rondani

**Heringia salax** (Loew). Cent., vi, No. 39 (1865).
1886. *Pipiza pistica* Williston, Synop. N. A. Syrph., 29.

A ♀ from Monroe Canyon, Sioux County, August 9, 1908 (L. Bruner).

### **Chrysogaster** Meigen

KEY TO THE SPECIES

1. Base and tip of tibiae, or at least first two joints of tarsus, yellow or yellowish red; last section of fourth longitudinal vein rectangular; antennae elongate..... 2

   Legs wholly black; last section of fourth vein curved or bent..... 3

2. The last section of the fourth vein joins the third beyond the tip of second vein, rectangular, with a stump of a vein in the middle; second joint of antennae nearly as long as the third; eyes with linear markings.....*nitida*

   The last section of the fourth vein joins the third before the tip of the second; eyes unicolorous.....*pictipennis*

3. Epistoma produced forwards.....*robusta*

   Epistoma not produced forwards.....*nigripes*

**Chrysogaster nitida** Wiedemann. Auss. Zweifl. Ins., ii, 116 (1830); Williston, Synop. N. A. Syrph., 35 (1886); Townsend, Trans. Amer. Ent. Soc., xxii, 36 (1895).

Five ♂ ♂ and eight ♀ ♀ from Lincoln, Lancaster County; West Point, Cuming County, and Omaha, Douglas County, between April 22nd and September 11th.

**Chrysogaster pictipennis** (Loew). Cent., iv, 58 (1863); Williston, Synop. N. A. Syrph., 37 (1886); Hunter, Canad. Ent., xxix, 124 (1897).

Nine ♂ ♂ and six ♀ ♀ taken at Lincoln, Lancaster County; Roca, Lancaster County; Ashland, Saunders County; Cedar Bluffs, Saunders County; West Point, Cuming County; Broken Bow, Custer County; Mitchell, Scottsbluff County, and Glen, Sioux County, between April 30th and August 28th.

**Chrysogaster robusta** Shannon. Proc. Ent. Soc. Wash., xviii, 101 (1916).

A ♀ collected in the Bad Lands at the mouth of Monroe Canyon, Sioux County, May 28th, 1901 (L. Bruner).

**Chrysogaster nigripes** Loew. Cent., iv, 60 (1863); Williston, Synop. N. A. Syrph., 33 (1886).

A ♂ taken at Cedar Bluffs, Saunders County, in April.

### **Chilosia** Meigen

KEY TO THE SPECIES

Face bare; pile on mesonotum short; everywhere profoundly punctured ..... *punctulata*

(Face hairy; pile on mesonotum long; not profoundly punctured ..... *livida*)

**Chilosia punctulata** Hunter. Canad. Ent., xxix, 128 (1897).

This species is not represented in the University collection, altho it is recorded by Hunter as having been collected at West Point, Cuming County, on September 9th.

I take this opportunity to present the description of a new *Chilosa* from Colorado, as follows:

**Chilosia livida** n. sp.

♂. Length 9-11 mm. Eyes hairy. Face and cheeks a bright blue-green black, the ocular depression with a faint pinkish tinge, white pilose except the oral margin and tubercle, face deeply concave just below the base of the antennae where it is whitish pollinose. Front a dull blue-green black, with a longitudinal depression and covered with moderately long pale yellow pile.

Dorsum of thorax bright greenish black, covered with moderately long pale yellow pile; pleura colored like the dorsum of the thorax with long whitish pile. Scutellum bluish black.

Abdomen bluish black with a very faint greenish tinge, the first three tergites darker than those following due to a covering of short black hairs. Lateral margins of abdomen with long white pile. Venter whitish pilose.

Apices of femora and bases and apices of tibiae reddish brown. Wings brownish on the basal portion becoming lighter apically.

*Type.* Ute Creek, Costilla County, Colorado, 9,000 feet, June 29, 1907 (R. W. Dawson). ♂. University of Nebraska collection.

*Paratypes.* Ute Creek, Costilla County, Colorado, 9,000 feet June 24, 1907 (L. Bruner). Two ♂ ♂ University of Nebraska collection.

**Cartosyrphus** Bigot

KEY TO THE SPECIES

1. Body entirely shining.....*comosa*

   Body not entirely shining..... 2

2. Front nearly bare.....*laevifrons*

   (Front with long black pile.....*longipilosa*)

**Cartosyrphus comosa** (Loew). Cent., iv, 66 (1863); Williston, Synop. N. A. Syrph., p. 44 (1886).

Two ♀ ♀ taken at Sioux County, and Bellevue, Sarpy County, both in May.

**Cartosyrphus laevifrons** (Jones). Jr. N. Y. Ent. Soc., xv, 90 (1907). 1907. *Chilosia laevifrons* Jones, Jr. N. Y. Ent. Soc., xv, 90.

The ♂ type is from Roca, Lancaster County, Nebraska, May 12th, 1906, on *Fragaria virginiana* (P. R. Jones).

I append here the description of a new *Cartosyrphus* from Colorado:

**Cartosyrphus longipilosa** n. sp.

♂. Length 8-9 mm. Face shining black, front and vertex black with long black pile. Antennae reddish brown, arista black and pubescent.

Thorax metallic, but feebly shining, clothed with dusky yellow and black pile. Pleura with black pile. Scutellum black with bristles on the margin. Wings hyaline with the stigma brown, the last section of the fourth vein much longer than the posterior cross-vein.

Abdomen opaque black except the anterior angles of the second segment, a triangular spot on each side of the third segment, the fourth segment and the hypopygium which are metallic. Legs black with the apices of the femora and bases of the tibiae reddish.

*Type.* Ute Creek, Costella County, Colorado, 9,000 feet, July 6, 1907 (L. Bruner). ♂. University of Nebraska collection.

*Paratypes.* Ute Creek, Costilla County, Colorado, 9,000 feet, July 6, 1907 (L. Bruner). 6 ♂ ♂. University of Nebraska collection.

**Chalcomyia** Williston

**Chalcomyia aerea** (Loew). Cent., x, 53 (1872); Williston, Synop. N. A. Syrph., 126 (1886).

A ♀ collected at Cedar Bluffs, Saunders County, in April.

**Myiolepta** Newman

KEY TO THE SPECIES

1. Abdomen black ..... *nigra*

   Abdomen with luteous or yellow spots at the base..... *varipes*

**Myiolepta nigra** Loew. Cent., x, 54 (1872); Williston, Synop. N. A. Syrph., 129 (1886).

A ♀ from South Sioux City, Dakota County, July 22, 1912 (L. T. Williams).

**Myiolepta varipes** Loew. Cent., ix, 79 (1869); Williston, Proc. Amer. Phil. Soc., xx, 308 (1882); Synop. N. A. Syrph., 128 (1886).

Two ♂ ♂ from Lincoln, Lancaster County, and Fairmont, Fillmore County, on May 8, 1906 (L. Bruner) and June 16, 1915 (C. E. Mickel), respectively.

**Rhingia** Scopoli

**Rhingia nasica** Say. Jr. Acad. Nat. Sci. Phil., iii, 94 (1823); Williston, Synop. N. A. Syrph., 130 (1886).

Five ♂ ♂ and eleven ♀ ♀ taken at Lincoln and Roca, Lancaster County, and South Bend, Cass County, between April 29th and May 29th.

**Neoascia** Williston

**Neoascia globosa** (Walker). List., iii, 546 (1849); Williston, Synop. N. A. Syrph., 111 (1886).

1882. *metallica* Williston, Proc. Amer. Phil. Soc., xx, 515.

One ♀ from Bellevue, Sarpy County, May 9, 1908 (L. Bruner). This specimen is the variety *metallica* of Williston.

**Sphegina** Meigen

**Sphegina lobata** Loew. Cent., iii, 21 (1863); Williston, Synop. N. A. Syrph., 115 (1886).

A ♀ from Monroe Cayon, Sioux County, June 18, 1911 (R. W. Dawson).

SERICOMYINAE

**Condidea** Coquillett.

**Condidea lata** Coquillett. Canad. Ent., xxxix, 75 (1907).

Two ♀ ♀ from Jim Creek and Warbonnet Canyon, Sioux County, in June, 1901.

VOLUCELLINAE

KEY TO THE GENERA

1. Arista featherly plumose.....*Volucella*

   Arista very densely pulmose, appearing like a solid mass....*Copestylum*

**Volucella** Geoffroy

KEY TO THE SPECIES

1. Wings cloudy only on cross-veins; larger species; in front of scutellum a yellowish, rather obscure parallelogram, emarginate anteriorly; abdomen yellow with narrow black posterior margins; face yellow.....*satur*

Wings with cloudiness other than on cross-veins; smaller species; in front of scutellum two yellowish oval spots; abdomen with three rather broad yellow bands.....*fasciata*

**Volucella satur** Osten Sacken. West. Dipt., 333 (1877); Williston, Synop. N. A. Syrph., 142 (1886).

Two ♂ ♂ and five ♀ ♀ collected in the western part of the state at Glen, Sioux County; Monroe Canyon, Sioux County, and Bad Lands, Sioux County, in August (12-19).

**Volucella fasciata** Macquart. Dipt. Exot., ii, 2, 22 (1842); Osten Sacken, West. Dipt., 334 (1877); Williston, Synop. N. A. Syrph., 145 (1886).

Eight ♂ ♂ and ten ♀ ♀ collected from the following localities: Warbonnet Canyon, Sioux County; Monroe Canyon, Sioux County; Glen, Sioux County; Imperial, Chase County; Haigler, Dundy County; Hitchcock County; Curtis, Frontier County; Gordon, Sheridan County; Mouth of Gordon Creek, Sheridan County; Halsey, Thomas County; Springview, Keyapaha County, and Lincoln, Lancaster County, between April 18th and September 30th.

### **Copestylum** Macquart

**Copestylum marginatum** (Say). Jr. Acad. Nat. Sci. Phil., vi, 167 (1829); Williston, Synop. N. A. Syrph., 151 (1886).

Three ♂ ♂ and two ♀ ♀ taken at Crawford, Dawes County; Haigler, Dundy County, and Halsey, Thomas County, between May 25th and August 12th.

### Eristalinae

KEY TO THE GENERA

1. Marginal cell closed.....*Eristalis*

   Marginal cell open..... 2

2. No stigmatical cross-vein; epaulet at base of costa broad and clothed with mostly yellowish hairs; squamae broad, bordered

by dense, straight (*H. similis, latifrons*) or branched (*H. conostomus, laetus, chrysostomus, integer*) cilia.....*Helophilus*

Stigmatical cross-vein present..... 3

3. Less pilose; eyes of male broadly separated; in the male hind coxae, hind femora, and tip of hind tibiae provided with spurs or protuberances; abdomen of male narrowed posteriorly (*Triodontia*) .....*Polydontomyia*

More pilose; eyes of male contiguous; in the male hind coxae, hind femora, and tip of hind tibiae not provided with spurs or protuberances; abdomen of male not narrowed posteriorly....*Mallota*

### **Eristalis** Latreille

KEY TO THE SPECIES

1. Eyes bare with small round dark spots; dorsum of thorax in female distinctly vittate; abdomen without light markings.....*aeneus*

Eyes pilose..... 2

2. Thorax with transverse bands; front in female narrowed above ..... *transversus*

Thorax without such bands..... 3

3. Mesonotum with four opaque black stripes, the median pair in the shape of a tuning fork.....*furcatus*

Mesonotum not so marked..... 4

4. Third segement of abdomen wholly shining, without opaque spots or bands (opaque spots in ♂ *latifrons*, opaque bands in ♂ *nitidus*) ..... 5

Third abdominal segment with opaque markings..... 7

5. Pile of eyes not confined to a vertical stripe; the black of second abdominal segment, at least in part, opaque (except ♀ *latifrons*) ..... 11

Pile of eyes mostly confined to a vertical stripe; the abdomen wholly shining; large species..... 6

6. Honey-bee like in appearance; moderately pilose; base of tibiae yellowish, posterior tarsi blackish; arista nearly bare.....*tenax*

Humble-bee like in appearance; thorax and abdomen with thick, long pile (on the dorsum of thorax sometimes blackish pilose (var. *melanostomus*); arista plumose; hind tarsi red.....*flavipes*

7. Third abdominal segment with a posterior, velvety black cross-band not interrupted in the middle..... 8

Third segment with three opaque spots; an elongated one on each side behind, and an oval median one in front; the opaque of second segment with a triangular shining spot behind; fourth segment with an oval opaque spot in front.....*dimidiatus*

8. Third segment of the abdomen broadly and conspicuously yellow on the sides (not so in ♀), joining the yellow of the second segment, the black of the second segment wholly opaque, not extending outwards on the sides behind; third segment with an opaque spot in front; fourth segment metallic, usually with a small opaque spot in front.....*meigenii*

The third segment not conspicuously yellow on the sides; the posterior opaque fascia of the second segment behind reaching toward the lateral margin (*meigenii* ♀)..... 9

9. Male with anterior velvety-black cross-band not interrupted in the middle on the third and fourth segments; female with no velvety black cross-bands on third and fourth segments.....*nitidus*

Male with only an anterior opaque spot on the third and fourth segments (not sure of *inornatus* ♂); female with or without anterior opaque spot on the third and fourth segments..... 10

10. Lighter markings of abdomen usually quite distinct; third and fourth segments with a small elongate, opaque black spot in front .....*temporalis*

Lighter markings obsolete, third and fourth segments without opaque anterior spot.....*inornatus*

11. Second, third and fourth segments of abdomen broadly reddish on sides, leaving a narrow black stripe, which is wholly opaque on the segment, and in front, at least, on the third segment; eyes narrowly separated (♂).....*montanus*

Second segment of abdomen only yellow on sides, with a posterior, interrupted or subinterrupted velvety cross-band; posterior margin of segments 2-4 yellowish white with a fringe of pale golden yellow hairs.....*latifrons*

**Eristalis aeneus** (Fabricius). Ent. Syst., iv, 302 (1772-94); Williston, Synop. N. A. Syrph., 161 (1886).

Thirty-two ♂ ♂ and twenty-six ♀ ♀ collected in the eastern part of the state at the following places: Lincoln, Lancaster County; West Point, Cuming County, and Omaha, Douglas County, between April 10th and November 1st.

**Eristalis transversus** Wiedemann. Auss. Zweifl. Ins., ii, 188 (1828); Williston, Synop, N. A. Syrph., 170 (1886).

Three ♂ ♂ and five ♀ ♀ taken at Brock, Nemaha County; South Bend, Cass County, and Lincoln, Lancaster County, in May and July.

**Eristalis furcatus** Wiedemann. Auss. Zweifl. Ins., ii, 176 (1828); Williston, Trans. Amer. Ent. Soc., xv, 279 (1888).

A ♀ is at hand labeled "Lincoln, Lancaster County, June." Heretofore at least, to the knowledge of the writer, this species has never been collected farther north than Brownsville, Texas, and in no great numbers north of Central America. I am unable to acount for its occurence in this state. With only one specimen in the collection there is a chance of it having been wrongly labeled.

**Eristalis tenax** (Linnaeus). Syst. Nat., 10th ed., 591 (1758); Osten Sacken, Ent. Mo. Mag., xxiii, 97 (1883); Williston, Synop. N. A. Syrph., 160 (1886).

Twelve ♂ ♂ and twenty ♀ ♀ taken at Monroe Canyon, Sioux County; Glen, Sioux County; Gordon, Sheridan County; West Point, Cuming County; Coburn, Dakota County; Lincoln, Lancaster County; Malcolm, Lancaster County; Louisville, Cass County, and Omaha, Douglas County, between June 3rd and November 14th.

**Eristalis flavipes** Walker. List., iii, 633 (1849); Williston, Synop. N. A. Syrph., 168 (1886); Hunter, Canad. Ent., xxviii, 99 (1896).

Five ♂ ♂ and seven ♀ ♀ taken at Omaha, Douglas County;

Lincoln, Lancaster County; Roca, Lancaster County, and Scottsbluff County, between March 31st and October 11th.

**Eristalis dimidiatus** Wiedemann. Auss. Zweifl. Ins., ii, 180 (1828); Williston, Synop. N. A. Syrph., 162 (1886).

Fourteen ♂ ♂ and three ♀ ♀ from Omaha, Douglas County; Lincoln, Lancaster County; Roca, Lancaster County; Fremont, Dodge County; South Bend, Cass County; Concord, Dixon County, and West Point, Cuming County, between March 31st and July 13th.

**Eristalis meigenii** Wiedemann. Auss. Zweifl. Ins., ii, 177 (1828).
1877. *androclus* Osten Sacken, West. Dipt., 337.
1886. *brousi* Williston, Synop. N. A. Syrph., 165.

Five ♂ ♂ taken at Omaha, Douglas County, and Mitchell, Scottsbluff County, between June 17th and August 22nd.

**Eristalis temporalis** Thomson. Eugen. Resa., 490 (1868).
1865. *hirtus* Loew, Cent., vi, 66, Osten Sacken, West. Dipt., 335 (1877); Williston, Synop. N. A. Syrph., 162 (1886).

Three ♂ ♂ and eight ♀ ♀ taken at Warbonnet Canyon, Sioux County; Mouth of Monroe Canyon, Sioux County; Harrison, Sioux County; Glen, Sioux County; Mitchell, Scottsbluff County, and Omaha, Douglas County, between May 29th and August 20th.

**Eristalis inornatus** Loew. Cent., vi, 68 (1865); Williston, Synop. N. A. Syrph., 175 (1886).

A ♀ taken in the Bad Lands, mouth of Monroe Canyon, Sioux County, May 28, 1911 (L. Bruner).

**Eristalis montanus** Williston. Proc. Amer. Phil. Soc., xx, 322 (1882); Synop. N. A. Syrph., 166 (1886); Hunter, Canad. Ent., xxviii, 98 (1896).

One ♀ and two ♂ ♂ taken at Lincoln, Lancaster County, April 6, 1918 (L. Bruner) and in Sioux County.

**Eristalis latifrons** Loew. Cent., vi, 65 (1865); Williston, Synop. N. A. Syrph., 164 (1886).
1877. *stipator* Osten Sacken, West. Dipt., 336.

Fifty-eight ♂ ♂ and ninety-nine ♀ ♀ taken at the following localities: Monroe Canyon, Sioux County; Glen, Sioux County; Mitchell, Scottsbluff County; Bridgeport, Morrill County; Haigler, Dundy County; Hitchcock County; McCook, Redwillow County; Curtis, Frontier County; Halsey, Thomas County; Gordon, Sheridan County; Carns, Keyapaha County; Concord, Dixon County; Maskell, Dixon County; Coburn, Dakota County; West Point, Cuming County; Lincoln, Lancaster County; South Bend, Cass County; Louisville, Cass County; Fairmont, Filmore County; Omaha, Douglas County, and Rulo, Richardson County, between May and October.

The description of a new *Eristalis* from Colorado is here appended:

**Eristalis nitidus** n. sp.

♀. Length 10-12.5 mm. Face shining black covered with a dense white pollen except the tubercle and nearly all the front. Front wide with white and black pile, the white pile being just above the base of the antennae. Occiput with long pale hairs. Eyes dark pilose. Antennal pits yellowish. First and second joints of antennae black, the third brownish- black and nearly quadrate.

Thorax bluish-black, little shining, densely covered with moderately long pale yellowish pile. Pleura bluish-black, clothed in long whitish pile. Scutellum with a reddish yellow cast and clothed with pale yellowish pile.

Abdomen shining bluish-black with the posterior margin of each segment, except the first, reddish yellow. First segment covered with white pollen, clothed with white pile, the remaining segments with black pile on the dorsum and white pile on the margins.

Femora except the apices, basal half of all the tibiae, and the tarsus except the first two joints of the middle and hind pairs, blackish, the remaining portion of the legs yellowish.

Wings hyaline except a brown spot at the base and another across the center of the wing.

♂. Length 10-11 mm. Similar to the female. The second segment of the abdomen has a triangular yellow spot on each side, the third segment has an anterior and posterior uninterrupted opaque band, and

the fourth segment has an anterior opaque band. The lighter hairs of the body are yellowish. The brown spots on the wings are distinctly marked. The yellow of the legs is less extended, especially on the tibiae.

This species was determined by Jones* as *saxorum*. It may be distinguished from *saxorum* by the broader front and the absence of velvety-black cross-bands on the abdomen in the female, the absence of a velvety cross-band on the posterior margin of the fourth segment in the male, and the less distinctly shining steel blue color of the entire body.

*Type.* Pike's Peak, Colorado, July 20, 1906 (L. Bruner). ♀. University of Nebraska collection.

*Allotype.* Pike's Peak, Colorado, July 20, 1906 (L. Bruner). ♂. University of Nebraska collection.

*Paratypes.* Pike's Peak, Colorado, July 20, 1906 (L. Bruner). 4♀♀, 3♂♂. University of Nebraska collection.

### **Helophilus** Meigen

KEY TO THE SPECIES

1. Face jutting forward into a cone.....*conostomus*

   Face not conically produced forwards..... 2

2. Sixth longitudinal vein distinctly sinuous..... 3

   Sixth longitudinal vein nearly straight or only gently curved.... 4

3. Front of female black pilose; front of male narrowed above....*similis*

   Front of female black pilose only near the ocelli; front of male broad .....*latifrons*

4. Abdomen elongate, cylindrical in the male..... 5

   Abdomen oval; face yellow..... 6

5. Hind coxae of the male with a stout process below.....*chrysostomus*

   (Hind coxae of the male not with a stout process .....*distinctus* Willst).

6. Luteous fasciae of the abdomen broad, the first narrowly interrupted, the remainder entire.....*integer*

   Fascia on the third segment narrowly interrupted.....*laetus*

*Ent. News, xviii, p. 241.

**Helophilus conostomus** Williston. Synop. N. A. Syrph., 193 (1886).

Two ♀ ♀ taken at South Sioux City, Dakota County, and West Point, Cuming County, in June and July.

**Helophilus similis** Macquart. Dipt. Exot., ii, 2, 64 (1842); Williston, Synop. N. A. Syrph., 189 (1886).

Five ♂ ♂ and six ♀ ♀ collected at Lincoln, Lancaster County; Cedar Bluffs, Saunders County, and Hardy, Nuckolls County, in April and August.

**Helophilus latifrons** Loew. Cent., iv, 73 (1863); Williston, Synop. N. A. Syrph., 188 (1886); Hunter, Canad. Ent., xxix, 138 (1897).

Thirty-six ♂ ♂ and thirty-nine ♀ ♀ taken at Omaha, Douglas County; Louisville, Cass County; South Bend, Cass County; Wabash, Cass County; Lincoln, Lancaster County; Cedar Bluffs, Saunders County; Ashland, Saunders County; Hardy, Nuckolls County; West Point, Cuming County; Neligh, Antelope County; Niobrara, Knox County; Concord, Dixon County; Carns, Keyapaha County; Halsey, Thomas County; Valentine, Cherry County; Haigler, Dundy County; Bridgeport, Morrill County; Mitchell, Scottsbluff County; Gering, Scottsbluff County; Gordon, Sheridan County; Crawford, Dawson County; Glen, Sioux County, and Bad Lands, mouth of Monroe Canyon, Sioux County, between May 8th and October 6th.

**Helophilus chrysostomus** (Wiedemann). Auss. Zweifl. Ins., ii, 174 (1828); Wiliston, Synop. N. A. Syrph., 190 (1886).

Five ♂ ♂ taken at Lincoln, Lancaster County, and Mitchell, Scottsbluff County in July and September.

**Helophilus integer** Loew. Cent., iv, 76 (1863); Williston, Synop. N. A. Syrph., 195 (1886); Hunter, Canad. Ent., xxiv, 139 (1897).

Two ♂ ♂ and twelve ♀ ♀ taken at Omaha, Douglas County; Lincoln, Lancaster County; West Point, Cuming County, and Mitchell, Scottsbluff County, between June 13th and August 12th.

**Helophilus laetus** Loew. Cent., iv, 77 (1863); Williston, Synop. N. A. Syrph., 189 (1886); Hunter, Canad. Ent., xxix, 139 (1897).
1895. *aureopilis* Townsend, Trans. Amer. Ent. Soc., xxii, 51.

Five ♂ ♂ and one ♀ from Omaha, Douglas County; Lincoln, Lancaster County; Sandhills, and Mitchell, Scottsbluff County, June 13th to September 10th.

### **Polydontomyia** Williston

**Polydontomyia curvipes** (Wiedemann). Auss. Zweifl. Ins., ii, 149 (1828).
1886. *Triodonta curvipes* Williston, Synop. N. A. Syrph., 206.
1877. *Polydontia curvipes* Osten Sacken, West. Dipt., 338.

Three ♂ ♂ and six ♀ ♀ taken at Lincoln, Lancaster County; Haigler, Dundy County, and Mitchell, Scottsbluff County between June 23rd and August 24th.

### **Mallota** Meigen

KEY TO THE SPECIES

1. Eyes pilose; more or less of the base of the abdomen with yellow pile.....*posticata*

   Eyes bare..... 2

2. Eyes contiguous in the male; abdomen almost wholly black pilose; hind tibiae of the male with a stout spur in the middle (form *bautias*) or wholly without such spur.....*cimbiciformis*

   Eyes separated in the male..... 3

3. Larger species; black facial stripe broad; abdomen black with yellow hair on the base and apex; legs mostly blackish in color .....*fascialis*

   Smaller species; black facial stripe narrow; abdomen black clothed with light colored pile; legs mostly reddish.....*illinoisensis*

**Mallota posticata** (Fabricius). Syst. Antl., 237 (1805); Williston, Synop. N. A. Syrph., 201 (1886).

Three ♂ ♂ and three ♀ ♀ taken at Rulo, Richardson

County; Omaha, Douglas County, and Nebraska City, Otoe County, from July 2nd to September 14th.

**Mallota cimbiciformis** (Fallen). Syrphici., 27; Williston, Synop. N. A. Syrph., 202 (1886); Hunter, Canad. Ent., xxviii, 99 (1896).

A ♀ collected at Milford, Seward County, in June.

**Mallota fascialis** Hunter. Canad. Ent., xxviii, 100 (1896).

Six ♂♂ and six ♀♀ taken at Warbonnet Canyon, Sioux County; Bad Lands, mouth of Monroe Canyon, Sioux County; Pine Ridge, Dawes County, and Lincoln, Lancaster County, between June 8th and July 8th, including the type specimen of the species.

**Mallota illinoisensis** Robertson. Canad. Ent., xxxiii, 284 (1901).

A ♂ from West Point, Cuming County, June 22nd (P. R. Jones).

### Milesinae

### Milesia Latreille

**Milesia virginiensis** (Drury). Illust. Exot. Ent., App., 11 (1770-82). 1886. *ornata* Williston, Synop. N. A. Syrph., 255.

A ♂ and three ♀♀ taken at Rulo, Richardson County; Omaha, Douglas County; Meadow, Sarpy County, and Lincoln, Lancaster County, from June 27th to July 31st.

### Xylotinae

KEY TO THE GENERA

1. Thorax with distinct yellow markings besides those on humeri and a single spot on the pleurae. "Wasp flies"..... 7

   Thorax without distinct yellow markings of the ground color except (certain species of *Cynorrhina* and *Somula*) rarely on the humeri and a single spot on the pleurae..... 2

2. Apical cross-vein sinuate, forming a sprawling "W"; anal furrow less than one-third the length of anal cell; all basal cells desti-

tute of the usual clothing of villi, causing the wings to have a glassy appearance; hind femora a little shorter than two and one-half times their width, and are held in longitudinal groove-like impressions of the abdomen during flight; chitinous parts of sternites only one-third the entire width of the abdomen; head subhemispherical, the eyes composing the greater part of the head; face subcarinate.....*Syritta*

Without the above conglomeration of characters..... 3

3. Hind femora with an apical saw-tooth prominence; face subcarinate to carinate.....*Tropidia*

Hind femora without a saw-tooth prominence; face not carinate 4

4. Third vein with a downward loop into first posterior cell; mesonotum ochraceous, very densely pollinose above.....*Pterallastes*

Third vein straight or with a very gentle downward curve..... 5

5. Epistoma abruptly truncate, face in profile deeply and evenly concave; first posterior cell closed, petiolate.....*Xylota*

Epistoma produced either well forward or protruding downward 6

6. Antennae inserted on prominence slightly higher than vertex of head; lateral margins of abdomen yellow.....*Somula*

Antennae inserted below vertex of head; lateral margins of abdomen not entirely yellow.....*Cynorrhina*

7. Antennae inserted near middle of head; face not longer than front .....*Temnostoma*

Antennae long or short and inserted above middle of head on a conical process; face much produced downwards; sixth vein entering wing margin shortly beyond anal cell.....*Sphecomyia*

Antennae inserted above middle of head; face not produced downwards; sixth vein prolonged obliquely outward from anal cell; hind femora with conical, tooth-like projection below near distal end.....*Spilomyia*

**Syritta** St. Fargeau and Serville

**Syritta pipiens** (Linnaeus). Syst. Nat., 10th ed., 594 (1758); Williston, Synop. N. A. Syrph., 240 (1886).

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Seventy ♂ ♂ and eighty-four ♀ ♀ taken at Rulo, Richardson County; Omaha, Douglas County; Child's Point, Sarpy County; Louisville, Cass County; South Bend, Cass County; Beatrice, Gage County; Lincoln, Lancaster County; Cedar Bluffs, Saunders County; Fairmont, Fillmore County; Concord, Dixon County; Curtis, Frontier County; Mitchell, Scottsbluff County; Glen, Sioux County; Harrison, Sioux County, and Monroe Canyon, between April 25th and September 27th.

### **Tropidia** Meigen

KEY TO THE SPECIES

1. Femora black, at the tip testaceous; the hind femora below, near the base, with a strong mammiform process (♂).....*mammillata*

   Front and middle femora yellow on distal end; hind femora without such process near the base.....*quadrata*

**Tropidia mammillata** Loew. Cent., i, 68 (1861); Williston, Synop. N. A. Syrph., 208 (1886); Hunter, Canad. Ent., xxix, 144 (1897).

Three ♂ ♂ and one ♀ taken at Cedar Bluffs, Saunders County, in April.

**Tropidia quadrata** (Say). Amer. Ent., 1, (1824); Williston, Synop. N. A. Syrph., 207 (1886).

Twenty-five ♂ ♂ and seven ♀ ♀ taken at Lincoln, Lancaster County; Hickman, Lancaster County; West Point, Cuming County, and Mitchell, Scottsbluff County, between May 1st and September 16th.

### **Pterallastes** Loew

**Pterallastes thoracicus** Loew. Cent., iv, 80 (1863); Williston, Synop. N. A. Syrph., 198 (1886).

Two ♂ ♂ taken at Omaha, Douglas County, July 22, 1913 (L. T. Williams) and Fairmont, Fillmore County, June 16, 1915 (C. E. Mickel).

**Xylota** Meigen

KEY TO THE SPECIES

1. Legs wholly black; hind femora much thickened..... 2

   Legs not wholly black..... 3
2. Wholly black; wings black.....*chalybea*
   Abdomen chiefly red; the second segment with a basal black triangle; wings nearly hyaline.....*pigra*
3. Second and third abdominal segments (at least) red..... 4

   Second and third segments wholly black, or with yellow spots.... 5
4. Abdomen wholly red except the first segment; hind coxae of the male without a tooth below.....*bicolor*

   Abdomen except the first segment not wholly red; hind coxae of male with a spur below.....*flavitibia*
5. Abdomen long and slender, with two yellow spots on the second segment .....*angustiventris*

   Abdomen not unusually slender..... 6
6. Abdomen with two pairs of yellow spots..... 8

   Abdomen wholly black..... 7
7. Arista luteous at base.....*anthreas*

   Arista wholly black.....*obscura*
8. Hind femora much thickened, small species; arista yellow at the base .....*fraudulosa*

   Hind femora moderately thickened..... 9
9. Fourth abdominal segment brilliant bronze; third longitudinal vein gently curved.....*analis*

   Fourth abdominal segment black; third vein quite straight *ejuncida*

**Xylota chalybea** Wiedemann. Auss. Zweifl. Ins., ii, 98 (1828); Williston, Synop. N. A. Syrph., 233 (1886); Townsend, Trans. Amer. Ent. Soc., xxii, 53 (1895).

A ♂ taken at Omaha, Douglas County, June 11, 1913 (L. L. Williams).

**Xylota pigra** (Fabricius). Ent. Syst., iv, 295 (1772); Williston, Synop. N. A. Syrph., 227 (1886).

Six ♂ ♂ and four ♀ ♀ taken at Monroe Canyon and Warbonnet Canyon, Sioux County, from June 19th to August 24th.

**Xylota bicolor** Loew. Cent., v, 39 (1864); Williston, Synop. N. A. Syrph., 229 (1886).

A ♀ collected at Glen, Sioux County, July 12, 1910 (L. Bruner).

**Xylota flavitibia** Bigot. Annales, 546 (1884); Williston, Synop. N. A. Syrph., 228 (1886); Hunter, Canad. Ent., xxviii, 101 (1896).

Seven ♂ ♂ taken at Monroe Canyon, Sioux County; Bad Lands, mouth of Monroe Canyon, Sioux County; Warbonnet Canyon, Sioux County, and Glen, Sioux County, from May 28th to July 18th.

**Xylota angustiventris** Loew. Cent., vi, 58 (1865); Williston, Synop. N. A. Syrph., 231 (1886).
1886. *elongata* Williston, Synop. N. A. Syrph., 234.

Two ♂ ♂ have been taken at West Point, Cuming County, and Warbonnet Canyon, Sioux County, in June.

**Xylota anthreas** Walker. List., iii, 556 (1849); Williston, Synop. N. A. Syrph., 235 (1886).

A ♀ taken at Milford, Seward County.

**Xylota obscura** Loew. Cent., vi, 55 (1865); Williston, Synop. N. A. Syrph., 233 (1886).

A ♀ taken at Warbonnet Canyon in Sioux County.

**Xylota fraudulosa** Loew. Cent., v, 41 (1864); Williston, Synop. N. A. Syrph., 230 (1886); Hunter, Canad. Ent., xxviii, 101 (1896).

Five ♂ ♂ and two ♀ ♀ have been taken at Omaha, Douglas County; Milford, Seward County, and West Point, Cuming County, between June 21st and August 17th.

**Xylota analis** Williston. Synop. N. A. Syrph., 226 (1886); Hunter, Canad. Ent., xxviii, 100 (1896).

A ♂ from Warbonnet Canyon, Sioux County.

**Xylota ejuncida** Say. Amer. Ent., 1, (1824); Williston, Synop. N. A. Syrph., 229 (1886); Hunter, Canad. Ent., xxix, 143 (1897).

One ♂ and three ♀ ♀ from Monroe Canyon, Sioux County; Sowbelly Canyon, Sioux County, and West Point, Cuming County, taken from June 21st to August 20th.

**Somula** Macquart

**Somula decora** Macquart. Dipt. Exot., Suppl., iii, 57 (1847).
1886. *Criorhina decora* Williston, Synop. N. A. Syrph., 216.

A ♂ and ♀ taken at Dunbar, Otoe County, respectively on May 5 and 6, 1905 (M. H. Swenk).

**Cynorrhina** Williston

**Cynorrhina umbratilis** (Williston). Synop. N. A. Syrph., 212 (1886).

A ♀ taken at South Bend, Cass County, May 17, 1905 (P. R. Jones).

**Temnostoma** St. Fargeau and Serville.

**Temnostoma bombylans** (Fabricius). Syst. Antl., 189 (1895); Williston, Synop. N. A. Syrph., 250 (1886).

A ♀ taken at Neligh, Antelope County, June 22, 1909 (W. Thompson).

**Sphecomyia** Latreille

**Sphecomyia vittata** (Wiedemann). Auss. Zweifl. Ins., ii, 87 (1828); Williston, Synop. N. A. Syrph., 257 (1886); Hunter, Canad. Ent., xxviii, 101 (1896).

Two ♂ ♂ and two ♀ ♀ collected at Lincoln, Lancaster

County; South Bend, Cass County, and Sioux County, all in May.

### **Spilomyia** Meigen

KEY TO THE SPECIES

1. Second joint of antennae much longer than first; second segment of abdomen with a broad arcuate yellow band, the third and fourth with a slender median interrupted one.....*quadrifasciata*

   Second joint of antennae not much longer than the first, third with an entire yellow band.....*longicornis*

**Spilomyia quadrifasciata** (Say). Long's Exped., App., 377 (1824); Wiliston, Synop. N. A. Syrph., 248 (1886); Hunter, Canad. Ent., xxviii, 101 (1896).

Five ♂ ♂ and seventeen ♀ ♀ have been collected at the following localities: Omaha, Douglas County; Lincoln, Lancaster County; Hardy, Nuckolls County; Mouth of Gordon Creek, Sheridan County; Glen, Sioux County, and Monroe Canyon, between August 14th and September 22nd.

**Spilomyia longicornis** Loew. Cent., x, 49 (1872); Williston, Synop. N. A. Syrph., 245 (1886); Townsend, Trans. Amer. Ent. Soc., xxii, 54 (1895).

A ♂ taken at Omahá, Douglas County, September 8, 1913 (L. T. Williams).

### **Cerioides**

### **Cerioides** Rondani

KEY TO THE SPECIES

1. Antennal process of front not more than half as long as the first joint of antennae, almost wholly wanting, first joint of antennae very slender, nearly as long as the two following together; face vertical, not at all excavated in profile; second segment of the abdomen much constricted, third and fourth segments each with two arcuate spots.....*willistoni*

2. Antennal process slender, longer than first joint of antennae; second segment of abdomen not constricted.....*abbreviata*

**Cerioides willistoni** (Kahl). Kans. Univ. Quart., vi, 141 (1897).
1853. *Ceria signifera* Loew, Neue Beitr., i, 18; Williston, Synop. N. A. Syrph., 262 (1886).

Three ♀ ♀ collected at Lincoln, Lancaster County, in March and May.

**Cerioides abbreviata** (Loew). Cent. v, 48 (1865).
1886. *Ceria abbreviata* Williston, Synop. N. A. Syrph., 261.

Two ♂ ♂ and one ♂ collected at Lincoln, Lancaster County, and Bridgeport, Morrill County, from May 17th to July 11th.

# A SYNOPSIS OF THE SCARABAEIDAE OF NEBRASKA (COLEOPTERA)

BY R. W. DAWSON

LINCOLN, NEBRASKA

Several years ago the writer undertook a study of the "June-bug" family (Scarabaeidae) for the state of Nebraska. The object of the study was two fold: First to determine the number and status of our species in this large and economically important family, and second to present a taxonomic review which would enable the beginning student, or interested amateur, to readily name with reasonable certainty any species which he might encounter in the state.

In the following pages 40 genera and 162 species are tabulated, and notes given on the abundance, seasonal and geographical distribution of the species within the state. Fourteen species are included without definite records of capture, because of their known distribution being such as to practically insure their ultimate discovery in Nebraska. The list is thought to be fairly representative; however, continued collecting will undoubtedly bring to light a considerable number of additional species. In order to more readily enable the student to recognize and determine these additional species the more important and useful papers have been listed under each genus.

The collection of the Department of Entomology contains a wealth of material in this family from other states, in fact about 280 species most of which are unlike those in the Nebraska fauna. The determination of this supplementary material has considerably increased the labor involved in presenting the present paper, but the writer judges the time well spent because of the light thrown upon the Nebraska fauna in consequence of the study of these related forms. Seven undescribed species have come to light from Nebraska

during the progress of this work. Four of these have already been published by the writer in his studies on the genus *Serica;* two are now in press in a short revision of the genus *Bolbocerosoma* by the writer and Mr. McColloch, and one in the genus *Lygerodes* has been assigned to Mr. Casey for description.

In the following pages the writer has tried to continually keep in mind the needs of the beginning student and has spared no pains to make the tables easy and workable, the most evident and readily described characters available being employed in constructing the tables, regardless of their fundamental taxonomic value. Since then, the statements of the fundamental group characters have thus largely been disassociated from the generic tabulation it has seemed desirable to incorporate them in the body of the text under the major headings.

The student should not gain the notion that the *Scarabaeidae* have been fully and adequately studied, and that little new is to be added to the knowledge of the family, for such is far from the situation. Perhaps the most striking example of the inadequacy of the literature is the case of the genus *Serica,* where the writer has found more than fifty undescribed species. In fact the presentation of this review has long been delayed because of the impossibility of naming the Nebraska species in this genus until the main facts concerning it were worked out for the whole of the North American fauna. Much is yet to be learned concerning the following Genera: *Trox, Serica, Diplotaxis, Phyllophaga, Polyphylla, Hoplia, Anomala, Cyclocephala, Ligyrus, Euphoria, Cremastochilus and Trichius.* Any or all of these genera could well be restudied monographically.

The family *Scarabaeidae* is a remarkably interesting one for the systematist. He can revel in studies of individual and subspecific variation, and the correlations of variation with geographical distribution in such genera as *Hoplia, Phyllophaga, Anomala, and Euphoria* until he becomes con-

vinced that the only major differences are truly specific after all. Then he can turn to *Serica* only to discover, through the phenomenal characters in the male genitalia, that the species may be legion, and differ from each other only by minor, or almost wholly negligible, external characters. At this juncture he may well take up *Polyphylla, Cyclocephala and Ligyrus,* where both external and genital characters seem inadequate, and ponder the advisability of the monographer making life-history studies and chromosome counts before finally deciding the limits and nature of the species.

In concluding these remarks thanks are due to many persons for aid in accumulating the collection and kindly loaning much of the material that has been at the writers disposal. Especially are acknowledgements due to Professors Lawrence Bruner and Myron H. Swenk for encouragement and direction in the work.

## SYSTEMATIC SYNOPSIS OF NEBRASKA SCARABAEIDAE

Family **SCARABAEIDAE**:

Subfamily LAPAROSTICTI:

Tribe Coprini:

| | | | |
|---|---|---|---|
| Genera: | *Canthon* | ( 7) | [2]* |
| | *Choeridium* | ( 1) | |
| | *Copris* | ( 1) | [1] |
| | *Phanaeus* | ( 1) | |
| | *Onthophagus* | ( 5) | |

Tribe Aphodiini:

| | | | |
|---|---|---|---|
| Genera: | *Aegialia* | ( 2) | |
| | *Aphodius*.. | (19) | |
| | *Ataenius* | ( 5) | [1] |
| | *Psammobius* | ( 1) | |
| | *Rhyssemus* | ( 1) | [1] |

Tribe Orphnini:

| | | | |
|---|---|---|---|
| Genus: | *Ochodaeus* | ( 3) | [1] |

Tribe Geotrupini:

| | | | |
|---|---|---|---|
| Genera: | *Odontaeus* | | [2] |
| | *Bolbocerosoma* | ( 2) | [1] |
| | *Eucanthus* | ( 1) | |
| | *Geotrupes* | ( 3) | |

*Figures in parenthesis indicate the number of species taken in the state, figures in square brackets the number included without definite records.

Tribe Glaphyrini:

| | | | |
|---|---|---|---|
| Genus: | *Amphicoma* | ( 1) | |

Tribe Trogini:

| | | | |
|---|---|---|---|
| Genera: | *Glaresis* | ( 1) | |
| | *Trox* | (12) | [1] |

Subfamily Melolonthinae:

Tribe Sericini:

| | | | |
|---|---|---|---|
| Genus: | *Serica* | ( 9) | |

Tribe Melolonthini:

| | | | |
|---|---|---|---|
| Genera: | *Diplotaxis* | ( 7) | [2] |
| | *Diazus* | ( 1) | |
| | *Phyllophaga* | (24) | [1] |
| | *Polyphylla* | ( 2) | |

Tribe Machrodactylini:

| | | | |
|---|---|---|---|
| Genera: | *Dichelonyx* | ( 4) | |
| | *Macrodactylus* | ( 1) | |

Tribe Hopliini:

| | | | |
|---|---|---|---|
| Genus: | *Hoplia* | ( 1) | |

Subfamily Pleurosticti:

Tribe Rutelini:

| | | | |
|---|---|---|---|
| Genera: | *Anomala* | ( 4) | |
| | *Strigoderma* | ( 1) | |
| | *Pelidnota* | ( 1) | |
| | *Cotalpa* | ( 2) | |

Tribe Dynastini:

| | | | |
|---|---|---|---|
| Genera: | *Cyclocephala* | ( 4) | |
| | *Dyscinetus* | ( 2) | |
| | *Ligyrodes* | ( 2) | |
| | *Ligyrus* | ( 2) | |
| | *Aphonus* | ( 1) | |

Tribe Cetoniini:

| | | | |
|---|---|---|---|
| Genera: | *Euphoria* | ( 6) | |
| | *Cremastochilus* | ( 5) | |
| | *Osmoderma* | ( 1) | [1] |
| | *Trichius* | ( 1) | |
| | *Valgus* | ( 1) | |

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## SCARABAEIDAE

Antennae inserted under the sides of the front, before the eyes, 7– to 11–segmented (usually 10–segmented), the distal segments, usually three in number (sometimes as many as seven), produced transversely, forming a club of thin plates which are capable of mutual contact throughout their length.

### SYNOPSIS OF THE GENERA

1. Last abdominal spiracle covered by the elytra ..... 2

   Last abdominal spiracle not covered by the elytra ..... 18

2. Scutellum not visible, the inner edges of the elytra in contact clear to the base; hind tibae with only one spur ..... 3

   Scutellum visible, clearly separating the inner margins of the elytra at the base; hind tibiae with two spurs ..... 7

3. Middle and hind tibiae slender, curved and nearly parallel sided beyond the middle ..... (p. 171) *Canthon*

   Middle and hind tibiae much wider at the tip, the sides distinctly divergent beyond the middle ..... 4

4. Front coxae not prominent, very transverse, the axis nearly horizonal; upper surface bare, polished and shining (p. 175) *Choeridium*

   Front coxae prominent, the axis nearly vertical or erect ..... 5

5. Front legs without tarsi, middle and hind tarsi ending in a sharp, curved point, but without claws ..... (p. 177) *Phanaeus*

   Front legs with tarsi, and all tarsi with claws ..... 6

6. Elytra strongly furrowed or longitudinally grooved; larger species, 12-17 mm. in length ..... (p. 176) *Copris*

   Elytra more or less lined longitudinally, but not deeply furrowed; smaller species, 4-13 mm. in length .... (p. 178) *Onthophagus*

7. Front femora much wider than the others, usually held forward so as to largely conceal the under surface of the head and antennae; surface of body and elytra dull and opaque, often much roughened ..... (p. 198) *Trox*

   Front femora of usual form and not held so as to conceal the

under surface of the head and the antennae; surface of body and elytra either dull or polished..... 8

8. Mandibles visible beyond the clypeus..... 12

Mandibles not visible beyond the clypeus..... 9

9. Hind tarsi with short, triangular segments, the basal ones conspicuously wider than the terminal.....(p. 190) *Psammobius*

Hind tarsi with longer nearly cylindrical segments, the basal ones but little wider than the terminal..... 10

10. Surface of head and pronotum roughly granulate; pronotum with three or four raised, transverse lines.....(p. 190) *Rhyssemus*

Surface of head and pronotum punctured instead of granulate; pronotum without transverse, raised lines..... 11

11. Outer, dorsal angle of hind tibiae prolonged and spine-like .....(p 187) *Ataenius*

Outer, dorsal angle of hind tibae not prolonged into a spine .....(p. 180) *Aphodius*

12. Pronotum and elytra with fine, short, semi-erect, yellow hair.... 17

Pronotum and elytra without fine yellow hair..... 13

13. Size small, 5 mm. or less in length.....(p. 180) *Aegialia*

Size larger, 7 - 20 mm. in length..... 14

14. Surface of pronotum evenly convex, not coarsely punctured .....(p. 195) *Geotrupes*

Surface of pronotum not evenly convex, more or less grooved, ridged, or tuberculate, coarsely and unevenly punctured..... 15

15. Eyes entirely divided into an upper and lower portion..... 16

Eyes only partially divided.....(p. 195) *Eucanthus*

16. Mesosternum strongly elevated between and in front of the middle coxae which are narrowly separated by a metasternal process extending forward and uniting with the mesosternal prominence .....(p. 194) *Bolbocerosoma*

Mesosternum not elevated between and in front of the middle coxae; the coxae nearly or quite contiguous.....(p. 193) *Odontaeus*

17. Yellow hairs rather thickly and evenly distributed over the surface of the elytra.....(p. 191) *Ochodaeus*

    Yellow hairs arranged in very definite, single, longitudinal rows on the elytra.....(p. 198) *Glaresis*

18. Inner margins of elytra straight beyond the scutellum, and capable of being in contact nearly or quite to the apex..... 19

    Inner margins of elytra curved, not capable of contact beyond the middle; the tips widely separated.....(p. 197) *Amphicoma*

19. Hind tarsi with a single large claw.....(p. 227) *Hoplia*

    Hind tarsi with two claws..... 20

20. Hind coxae dilated into plates which usually cover all of the first and half of the second abdominal segments; the widest portion of the coxal plates about twice the width of the hind femora .....(p. 203) *Serica*

    Hind coxal plates but little dilated, the widest portion never twice the width of the femora, and first abdominal segment never covered at the middle by the coxal plates..... 21

21. Abdomen with the sixth ventral segment much reduced in size, often entirely covered by the fifth segment, in which case the abdomen appears to have only five ventral segments..... 22

    Abdomen with the sixth ventral segment clearly visible, not reduced in size..... 23

22. Tarsal claws simple, not toothed on the inner edge; antennae 9-segmented .....(p. 211) *Diazus*

    Tarsal claws cleft at the tip, or toothed on the inner edge; antennae 10-segmented.....(p. 207) *Diplotaxis*

23. Labium developed into a large concave plate concealing the other mouth parts, and usually the antennae as well..... .....(p. 241) *Cremastochilus*

    Labium of the usual form, not entirely covering the other mouth parts, and never concealing the antennae..... 24

24. Antennal club composed of five or six plates.....(p. 224) *Polyphylla*

    Antennal club composed of only three plates..... 25

25. Pronotum relatively large and broad, distinctly wider than long 29

    Pronotum relatively smaller, but little, and sometimes not at all wider than long..... 26

26. Elytra short, truncate, their length about equalling their combined width.....(p. 244) *Trichius*

    Elytra much longer, not truncate, length distinctly greater than their combined width..... 27

27. Elytra with numerous, very distinct, longitudinal grooves .....(p. 230) *Strigoderma*

    Elytra not distinctly, longitudinally grooved..... 28

28. Pronotum long and narrow, one and one-half times as long as its basal width.....(p. 227) *Macrodactylus*

    Pronotum much shorter, but little if any longer than wide .....(p. 225) *Dichelonyx*

29. Terminal portion of elytra with a very narrow membranous edge.....(p. 228) *Anomala*

    Terminal portion of elytra not having a membranous edge..... 30

30. Tarsal claws, especially the front ones, alike in size and shape 34

    Tarsal claws, especially the front ones, unequal, decidedly so in most males, but often only slightly so in the females..... 31

31. Pronotum with a narrow, but distinct rim or margin at the base ..... 33

    Pronotum not distinctly margined at the base..... 32

32. Front and clypeus separated by a ridge or keel; larger, blackish or dark grown species.....(p. 235) *Ligyrodes*

    Front and clypeus separated by an obscure suture; smaller, pallid or yellowish species.....(p. 232) *Cyclocephala*

33. Clypeus separated from the front by a distinct suture..... .....(p. 231) *Cotalpa*

    Clypeal suture nearly or quite obsolete.....(p. 231) *Pelidnota*

34. Epimera of mesothorax visible from above, at the base of the elytra ..... 39

    Epimera of mesothorax not visible from above..... 35

35. Front tibiae with five teeth on the outer edge.....(p. 244) *Valgus*

    Front tibiae with only three teeth on the outer edge..... 36

36. Clypeus separated from the front by a ridge or keel..... 38

Clypeus separated from the front by a more or less distinct suture ..... 37

37. Tarsal claws toothed.....(p. 211) *Phyllophaga*

Tarsal claws simple.....(p. 234) *Dyscinetus*

38. Mandibles visible from above, serrate or toothed on the outer margin .....(p. 236) *Ligyrus*

Mandibles usually not visible from above, and not toothed on the outer margin.....(p. 237) *Aphonus*

39. Epimera of mesothorax extending up between the rear corners of the pronotum and the base of the elytra.....(p. 237) *Euphoria*

Epimera of mesothorax below the rear corners of the pronotum, and not extending up between the pronotum and the base of the elytra .....(p. 243) *Osmoderma*

## LAPAROSTICTI

Abdominal spiracles situated in the membrane connecting the sternites and tergites, the last spiracle covered by the elytra; ligulae always distinct from the mentum; the species all living on decomposing organic matter, many of them in excrement and a few in fungi.

## COPRINI

Body relatively broad and rounded in outline; clypeus expanded covering the mouth parts; hind tibiae usually with a single spur; last tarsal segment usually without the two erect setae between the claws; elytra subtruncate, leaving the pygidium exposed; abdomen with six firmly united sternites.

### **Canthon** Hoffmansegg

The genus *Canthon* is peculiar to the New World, ninety seven species, mostly from tropical America, being recorded by Harold in his monograph. Of these only seven have thus far been taken in Nebraska, although at least two additional

forms probably occur in the state. Both as larvae and adults the species are dung feeders. To provide food for the larvae pellets of characteristic size and shape for the species are molded by the parent beetles and buried with an egg on each. *Canthon laevis,* our common, large tumble-bug makes spherical balls nearly an inch in diameter which one often sees them rolling in the pastures and road-sides. Judging from a few specimens at hand *nigricornis* forms egg-shaped pellets, and *praticola* rather narrow, elongate ones.

1817. Hoffmansegg: "Entomologische Bemerkungen . . . . . über amerikanishe Insecten . . . . . ," Wiedem. Mag. i, pt. i, p. 38.
1859. Le Conte: "Coleoptera of Kansas and Eastern New Mexico." Smithson. Cont. Knowl., xi, pp. 1-58. (Table for 12 species.)
1868. Harold: "Monographie der Gattung Canthon," Berl. Ent. Zeitschr., xii, pp. 1-144. (Table for 97 species.)
1870. Horn: "Notes on some Genera of Coprophagus Scarabaeidae of the United States," Trans. Amer. Ent. Soc., iii, pp. 42-51. (Revision, and table for 15 species.)
1885. Blanchard: "On the species of Canthon and Phanaeus of the United States with notes on other genera," Trans. Amer. Ent. Soc., xii, pp. 163-172. (Revision, and table for 15 species.)
1910. Blatchley: Coleoptera of Indiana, pp. 912-915. (Descriptive notes and table for 9 species).
1915. Schaeffer: "New Coleoptera and Miscellaneous Notes," Journ. N. Y. Ent. Soc., xxiii, pp. 47-55. (Two new varieties).

SYNOPSIS OF THE SPECIES

1. Hind tibiae with two spurs.....*nigricornis*

   Hind tibiae with one spur..... 2

2. Hind femora margined in front; size large, 12 - 18 mm..... 7

   Hind femora not margined in front, size moderate to small, 12 mm. or less..... 3

3. Sides of prothorax beneath transversely excavated anteriorly for the reception of the femora.....*viridis*

   Sides of prothorax beneath not transversely excavated..... 4

4. Subhumeral stria anteriorly, finely carinated..... 5

   Subhumeral stria not carinated anteriorly..... 6

5. Nearly smooth above.....*lecontei*

   Densely, but not coarsely, granulated above.....*praticola*

6. Coarsely and sparsely granulated; striae of elytra equal ..... [*depressipennis*]

   Finely and densely granulated; lateral striae of elytra deeper than the discal striae.....*ebenus*

7. Eyes large; antennae ferruginous.....[*vigilans*]

   Eyes normal; antennae black..... 8

8. Granules of pronotum and pygidium distinct.....*laevis*

   Pronotum and pygidium finely scabrous, without distinct granules .....*chalcites*

**Canthon nigricornis** Say.

1823. *Ateuchus nigricornis* Say, Journ. Acad. Nat. Sci. Phila., iii, pp. 207 - 208. Le Conte Ed., ii, p. 133.

Specimens examined: 11 ♂, 5 ♀, from Pine Ridge*, Brady Island, Dismal River, Halsey, and Watts Lake in Cherry Co., collected during May, June and July. Although the specimens at hand are all from central and western Nebraska, the known distribution of the species indicates that *nigricornis* should be found over the entire state, at least under favorable local conditions.

**Canthon ebenus** Say.

1823. *Ateuchus ebeneus* Say, Journ. Acad. Nat. Sci. Phila., iii, p. 209. Le Conte Ed., ii, p. 134.

Specimens examined: 20 ♂, 22 ♀, from Neligh, Culbertson, Haigler, Imperial, Brady Island, Halsey, Valentine, and the lake region of Cherry Co., collected during May, June and July. This common species is widely distributed, occuring from Maine to Texas.

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* "Pine Ridge" as used in this paper refers not to the town, but to the the pine clad hills of Sioux and Dawes counties.

[**Canthon depressipennis** Le Conte.

1859. *Canthon depressipennis* Le Conte, Coleoptera of Kansas and N. M., p. 10.

This species is recorded by Blanchard (1.c.) from Dakota and Kansas, but no specimens are at hand from Nebraska.]

**Canthon praticola** Le Conte.

1859. *Canthon praticola* Le Conte, Coleoptera of Kansas and N. M., pp. 10, 11.

Specimens examined: 7 ♂, 2 ♀, from Haigler, Mitchell, Gordon and Kearney, collected from May to August. *Praticola* is a western species which is probably less common, or absent, in the eastern part of the state.

**Canthon lecontei** Harold.

1868. *Canthon lecontei* Harold, Berl. Ent. Zeitschr., p. 68.

Specimens examined: 1 ♂, from Haigler, July 6, and 1 ♀, July 4, collected by J. T. Zimmer. The character "clypeus 6–dentate, or 4–dentate" used by Dr. Horn in his table for the separation of the closely similar species *probus* and *lecontei* is apparently unsatisfactory. Our Nebraska species is here referred to *lecontei* rather than *probus* because of the carination of the subhumeral stria.

[**Canthon vigilans** Le Conte.

1858. *Cathon vigilans* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iv, p. 16.

No Nebraska specimens of this species are at hand, but since it is a rather widely distributed form, and is recorded from Iowa, Missouri and Kansas, the writer has included it in the synopsis.]

**Canthon laevis** Drury.

1770. *Scarabaeus laevis* Drury, Exot. Ins., i, p. 79, pl. 35, fig. 7. Westwood Ed., 1837, i, p. 73, pl. 35, fig. 7.

Specimens examined: 33 ♂, 44 ♀, from South Sioux

City, Concord, Peru, Lincoln, Omaha, Scribner, Fairmont, West Point, Rock Co., Imperial, Mitchell, and Sioux Co., collected from April to August 17. *Laevis* is a common, widely distributed and variable species. The Nebraska specimens are largely of the usual bronzed-black type, but in an occasional individual the bronzed luster is nearly or quite wanting. Among the specimens at hand the length varies from 12 to 18 mm.

**Canthon chalcites** Haldeman.

1843. *Canthon chalcites* Haldeman, Proc. Acad. Nat. Sci. Phila., i, p. 404.

Specimens examined: 2 ♂, 3 ♀, collected at Omaha, Maskell and Rulo, during May, June and July.

**Canthon viridis** Beauvois.

1805. *Copris viridis* Beuvois, Ins. Afr. et Amer., p. 23 pl. 3, fig. 2.

Specimens examined: 1 ♀ ,from South Bend. This species is recorded from Indiana, the southern and western states, and Central America. It is probably rare in Nebraska.

**Choeridium** Serville

From the North American fauna only two species are known in this genus, one of more southernly and one of more northernly distribution. The latter is here recorded from Nebraska.

1825. Serville: Entomological part of Encyclopédie methodique, x, p. 356.

1885. Blanchard: "On the Species of Canthon and Phanaeus of the United States with Notes on other Genera," Trans. Amer. Ent. Soc., xii, pp. 163-172. (Descriptions of the two species.)

**Choeridium histeroides** Weber.

1801. *Copris histeroides* Weber, Obs. Ent., p. 37.

1910. *Choeridium histeroides* Blatchley, Coleoptera of Indiana, p. 915, fig. 361.

Specimens examnied: 1 ♂, Nebraska City, April 29, 1916, collected under leaves by R. W. Dawson. *Histeroides* is also recorded from Iowa.

**Copris** Geoffry

1762. Geoffry: "Historie abregee des insectes qui se trouvent aux environs de Paris," i, p. 87.
1870. Horn: "Notes of some Genera of Coprophagus Scarabaeidae of the United States," Trans. Amer. Ent. Soc., iii, pp. 42-51. (Descriptive notes and table for four species).
1906. Schaeffer: "On Bradycinetus and Bolboceras of North America, with Notes on other Scarabaeidae," Trans. Amer. Ent. Soc., xxxii, pp. 249-260. (Descriptive notes and table for seven species.)
1910. Blatchley: Coleoptera of Indiana, pp. 915-916. (Descriptive notes and tables for three species.)

SYNOPSIS OF THE SPECIES

1. Sides of pronotum sinuate near the front angles, surface of pronotum dull, coarsely and densely punctate; length 11 - 18 mm. ..... *tullius*

   Sides of pronotum not sinuate, thorax more or less shining, and unevenly punctured; length 8 - 11 mm..... [*minutus*]

**Copris tullius** Olivier.

1789. *Scarabaeus tullius* Olivier, Ent. Hist. Nat. Ins. Col., i, p. 118, pl. 11, fig. 98, pl. 19, fig. 88.

Specimens examined: 19 ♂, 26 ♀, from Nebraska City, Lincoln, Fremont, Hooper, West Point, Holt Co., and Haigler, collected from April 16 to August 16. The name *tullius* has priority over *anaglypticus* which has long been used for this species.

[**Copris minutus** Drury.

1773. *Scarabaeus minutus* Drury, Illustr. exot. Ins., ii, p. 78, pl. 35 fig. 6.

No specimens of this common and widely distributed east-

ern species are at hand from Nebraska, but it may occur in the southeastern part of the state.]

**Phanaeus** Mac Leay

Eight or nine species of these remarkbale beetles are known in the North American fauna, but only one has thus far been taken in Nebraska.

1819. Mac Leay: Horae Entomologicae, i, pt. i, 1. 124.
1885. Blanchard: "On the Species of Canthon and Phanaeus of the United States, with Notes on other Genera," Trans. Amer. Ent. Soc., xii, pp. 163-172. (Revision and table for seven species.)
1910. Blatchley: Coleoptera of Indiana, p. 917. (Descriptive notes on two species.)

**Phanaeus carnifex** Linnaeus.

1758. *Scarabaeus carnifex* Linnaeus, Systema Naturae, ed. x, p. 346.

Specimens examined: 5 ♂, 3 ♀, from Rulo, South Bend, Dismal River, Beaver City and Haigler, collected from May to August.

*Carnifex* occurs more commonly than one might suppose from the meager collection of specimens at hand. During June, 1917 the writer noted a considerable number of the "shells" of these beetles in the disgorged pellets of undigested food examined at a flourishing colony of Burrowing Owls located in a pasture about six miles east of Lincoln along the O Street Road. Evidently the owls at least, were able to find *carnifex* in some numbers.

This beetle is one of the most beautiful Scarabaeids occuring in the state. When captured its relatively large size, robust form, brilliant metallic green and bronzed coloration, and the remarkable horn on the head rarely fail to awaken the interest and curiosity of the finder. The elaborate dress seems strikingly out of harmony with the habit of burrowing in fresh cow dung, and doubtless inspired the name "Phanaeus carnifex", the "dirty devil".

**Onthophagus** Latreille

1807. Latreille: Genera Crustaceorum et Insectorum, p. 141.
1875. Horn: "Synonymical Notes and Descriptions of New Species of North American Coleoptera," Trans. Amer. Ent. Soc., v, pp. 126-156. (Descriptive notes and table for five species.)
1910. Blatchley: Coleoptera of Indiana, pp. 917-920. (Descriptive notes and table for five species.)
1914. Schaeffer: "A Short Review of the North American Species of Onthophagus," Journ. N. Y. Ent. Soc., xxii, pp. 290-300. (Descriptive notes and table for eighteen species.)

SYNOPSIS OF THE SPECIES

1. Surface of body polished and shining, length 10 - 13 mm.....*coproides*
   Surface of body more or less opaque or dull, length, scarcely, or not, exceeding 8 mm..... 2

2. Pronotum of male not differing from that of female, simple and convex in both sexes.....*pennsylvanicus*

   Pronotum of male protruberant in front, sometimes strongly so 3

3. Anterior margin of clypeus distinctly emarginate; pronotum of male with an obtuse, triangular lobe in front.....*anthracinus*

   Anterior margin of clypeus not distinctly emarginate, often rounded or produced medially into a reflexed process; pronotum of male frequently produced anteriorly into a long process more or less emarginate at the apex..... 4

4. Body black, opaque; thorax finely granulate; elytral intervals each with two rows of fine granules.....*hecate*

   Body shining, bluish, greenish or bronzed; thorax punctured; elytra not granulate.....*orpheus*

**Onthophagus coproides** Horn.

1881. *Onthophagus coproides* Horn, Trans. Kans. Acad. Sci., vii, pp. 75-76.

Specmiens examined: 1 ♂, collected at Halsey, August 23, 1921 by R. W. Dawson.

**Onthophagus hecate** Panzer.

1794. *Scarabaeus hecate* Panzer, Faun. Ins. Amer. Bor., p. 5, pl. i, fig. 2.

Specimens examined: 38 ♂, 133 ♀, from Maskell, South Sioux City, Fort Calhoun, Weeping Water, Nebraska City, Omaha, South Bend, Ashland, Fremont, Lincoln, Fairmont, West Point, Broken Bow, Valentine, Haigler, Harrison, Monroe and Warbonnet Canyons in Sioux Co., and Mitchell, collected working in the droppings of animals from March to October.

**Onthophagus orpheus** Panzer.

1794. *Scarabaeus orpheus* Panzer, Faun. Ins. Amer. Bor., p. 5, pl. i, fig. 2.

Specimens examined: 5 ♂, 1 ♀, from Fairmont, Halsey, Mitchell, and Warbonnet Canyon in Sioux Co., collected during June and August. *Orpheus* is a widely distributed species, but is much less common in Nebraska than *hecate*.

**Onthophagus pennsylvanicus** Harold.

1871. *Onthophagus pensylvanicus* Harold, Col. Hefte, viii, p. 115.

Specimens examined: 8 ♂, 16 ♀, from South Bend, Cedar Bluffs, Omaha, Lincoln, West Point, Neligh, Fairmont, Dismal River, Halsey, Mitchell, and Monroe Canyon in Sioux Co., collected during June, July and August.

**Onthophagus anthracinus** Harold.

1874. *Onthophagus anthracinus* Harold, Col. Hefte, xi, p. 104.

Specimens examined: 2 ♂, from Omaha, collected by L. T. Williams June 12, 1914. This species is probably rare or accidental in Nebraska. It is recorded from Texas, Arizona, Mexico and Central America.

APHODIINI

Size small, form cylindrical; posterior tibiae with two spurs; elytra not subtruncate, covering the pygidium; abdominal segments freely articulated; last segment of the tarsi with two erect setae.

### **Aegialia** Latreille

1907. Latreille: Genera Crustaceorum et Insectorum, p. 96.
1871. Horn: "Synopsis of Aphodiini of the United States," Trans. Amer. Ent. Soc., iii, pp. 284-297. (Descriptive notes and table for four species.)
1887. Horn: "A Monograph of the Aphodiini Inhabiting the United States", Trans. Amer. Ent. Soc., xiv, pp. 1-110. (Descriptive notes and table for ten species).

SYNOPSIS OF THE SPECIES

1. Thorax with distinct basal marginal line.....*conferta*

Thorax without basal marginal line.....*spissipes*

**Aegialia conferta** Horn.

1871. *Aegialia conferta* Horn, Trans. Amer. Ent. Soc., iii, pp. 293, 294.
1910. *Aegialia conferta* Blatchley, Coleoptera of Indiana, p. 921.

Specimens examined: 5, collected at West Point in June, 1888. This is probably the commonest and most widely distributed species of the genus, and doubtless occurs more frequently in the state than the material at hand would seem to indicate.

**Aegialia spissipes** Le Conte.

1878. *Aegialia spissipes* Le Conte, Proc. Amer. Philos. Soc., p. 611.

Specimens examined: 6, collected at West Point in June, 1888. *Spissipes* is less common than the preceding species. It is recorded from Michigan and Massachusetts.

### **Aphodius** Illiger

*Aphodius* is one of the largest genera in the family *Scarabaeidae*, and is represented in the North American fauna by 103 species. Many of these are widely distributed and several of them nearly cosmopolitan, which is a rather unusual circumstance among the higher groups of insects.

Of the nineteen species here recorded from Nebraska nine are represented in the collection by six or less specimens each. When a collection in such a group as this shows a considerable proportion of uniques the student is justified in assuming that it is not fully representative, and should therefore expect to find several additional forms.

1798. Illiger. Kugelann Verzeichniss der Kafer Preussens, P. 15.
1870. Horn: "Description of the Species of Aphodius and Dialytes of the United States", Trans. Amer. Ent. Soc., iii. pp. 110-134. (Descriptive notes and table for 51 species).
1887. Horn: "A Monograph of the Aphodiini Inhabiting the United States", Trans. Amer. Ent. Soc., pp. xiv, 1-110. (Descriptive notes and table for 81 species).
1910. Schmidt: "Coleoptera Lamellicornia Family Aphodiidae", Gen. Ins., fasc. 110, 155 pp. 3 pl. (Subgeneric tabulation and list of 108 North American species).
1910. Blatchley: Coleoptera of Indiana, pp. 927-935. (Descriptive notes and table for 20 species).

SYNOPSIS OF THE SPECIES

1. Apex of hind tibiae fringed with short equal spinules..... 2

   Apex of hind tibiae fringed with longer, unequal spinules..... 6

2. Mesosternum not carinated between the coxae..... 3

   Mesosternum distinctly carinated between the coxae..... 5

3. Head and pronotum black, elytra red, pronotum of male impressed in front .....*fimetarius*

   Head and pronotum colored like the elytra, brown or black..... 4

4. Clypeus with a distinct, transverse ridge.....*duplex*

   Clypeus without a transverse ridge.....*ruricola*

5. First segment of hind tarsi not longer than the next two together; color black; sutural interval of elytra as wide as or even wider than the second interval.....*granarius*

   First segment of hind tarsi equal to the next three together; elytra reddish brown, suture and side margins darker or blackish .....*vittatus*

6. Pronotum narrower at base than at apex; humeri of elytra dentiform .....*oblongus*

Pronotum not narrower at base than at apex ..... 7

7. Elytra not pubescent ..... 8

Elytra more or less pubescent ..... 15

8. Side margins of pronotum explanate, usually with a concavity near the hind angles ..... 9

Side margins of pronotum not explanate ..... 10

9. Elytra, sides of pronotum and head dull red ..... *explanatus*

Color uniformly dark brown ..... *brevicollis*

10. Mesosternum distinctly carinate between the coxae; pronotum without basal, marginal line; front tibiae punctate on the anterior face, first tarsal joint longer than the second ..... 11

Mesosternum not carinate between the coxae; anterior tibiae smooth in front ..... 12

11. Hind tibiae stout; first joint of hind tarsi not as long as the next three together ..... *rubeolus*

Hind tibiae slender; first joint of hind tarsi longer than the next three together ..... *stercorosus*

12. Uniformly reddish brown; length 8–9 mm ..... *concavus*

Largely or entirely black or piceous ..... 13

Elytra light brown or yellowish, either marked with black, or more or less clouded ..... 14

13. Body beneath and legs piceous ..... *coloradensis*

Body beneath and legs pale yellow; elytra often with the alternate intervals having small red spots ..... *bicolor*

14. Anterior margin of clypeus angulate at each side of the middle; smaller, length 4.5 mm. or less ..... *serval*

Anterior margin of clypeus broadly rounded at each side of the middle; larger, length 4.5 – 5.5 mm. ..... 18

15. Elytra reddish brown, head and thorax a little darker; length 3.4 – 4 mm. ..... *lentus*

Elytra, at least in part, yellowish, head and thorax largely black; length 4.5 – 6 mm. ..... 16

16. Elytra largely yellow, merely the suture darker ..... [*subtruncatus*]

Elytra clouded with fuscous ..... 17

17. Sides of pronotum fringed with rather long hairs; anterior tibiae with upper tooth small or wanting ..... *walshi*

Sides of pronotum not fringed with long hairs; front tibiae plainly tridentate ..... *femoralis*

18. Dark markings of elytra in the form of distinct streaks or spots ..... *distinctus*

Dark markings of elytra in the form of a large central clouded area, leaving only the margins pallid ..... *walshi*

**Aphodius fimetarius** Linnaeus.

1758. *Scarabaeus fimetarius* Linnaeus, Systema Naturae, ed. x, i, p. 348.

Specimens examined: 46 ♂, 55 ♀, from Omaha, Lincoln, Fairmont, Fremont, West Point, Halsey, Holt Co., Cherry Co., Glen, Monroe, Canyon in Sioux Co., and Mitchell, collected from February 22 to December 11. This is an abundant and essentially cosmopolitan species.

**Aphodius duplex** Le Conte.

1878. *Aphodius duplex* Le Conte, U. S. Geol. Surv., Bull. iv, pt. 2, p. 454.

Specimens examined: 1 ♂, collected in Warbonnet Canyon, Sioux Co. *Duplex* is doubtless uncommon in the state, and to be met with only in the western part. It is recorded from Colorado.

**Aphodius ruricola** Melsheimer.

1844. *Aphodius ruricola* Melsheimer, Proc. Acad. Nat. Sci. Phila., ii, p. 136.

Specimens examined: 54, from South Bend, Lincoln, West Point, Fairmont, Holt Co., Mitchell, and Warbonnet Canyon in Sioux Co., collected from April to August.

**Aphodius granarius** Linnaeus.

1767. *Scarabaeus granarius* Linnaeus, Systema Naturae, ed. xii, i, 2, p. 547.

Specimens examined: 164, from Omaha, Lincoln, Fairmont, West Point, Ravenna, and Mitchell, collected from April 4 to July 5. Like *fimetarius*, this is an European species which has become practically cosmopolitan. It is often seen flying in large numbers at sunset on warm spring evenings.

**Aphodius vittatus** Say.

1825. *Aphodius vittatus* Say, Journ. Acad. Nat. Sci. Phila., v, pp. 191-192. Le Conte ed., ii, p. 295.

Specimens examined: 53, from Fairmont, Holt Co., Halsey, Mitchell, and Warbonnet Canyon in Sioux Co., collected from May 16 to August 4. *Vittatus* is evidently much commoner in the western than the eastern part of the state, the majority of the specimens listed coming from Mitchell where the writer found the species abundant in middle June.

**Aphodius lentus** Horn.

1870. *Aphodius lentus* Horn, Trans. Amer. Ent. Soc., iii, pp. 124, 125.

Specimens examined: 6, five of these collected at West Point during May and June, 1888, and one in Monroe Canyon, Sioux Co., June, 1911. *Lentus* has been recorded from Massachusetts, Pennsylvania, Indiana, Georgia and Illinois.

**Aphodius explanatus** Le Conte.

1878. *Aphodius explanatus* Le Conte, U. S. Geol. Surv., Bull. iv, pt. 2, p. 457.

Specimens examined: 2 ♂, from Haigler, May 24, 1914. This is a Colorado species, and its range probably does not extend very far to the eastward in Nebraska.

**Aphodius brevicollis** Le Conte.

1878. *Aphodius brevicollis* Le Conte, U. S. Geol. Serv., Bull. iv, pt. 2, p. 455.

Specimens examined: 1 ♂, 2 ♀, from Lincoln, collected during November and December. The type of this species was taken in Nebraska, the exact locality being unknown.

**Aphodius rubeolus** Beauvois.

1805. *Aphodius rubeolus* Beauvois, Ins. Afr. et Amer., p. 90, pl. 2, fig. 4.

Specimens examined: 4, from Lincoln, West Point and Mitchell. *Rubeolus* is a rather widely distributed species, but apparently not very common in Nebraska.

**Aphodius stercorosus** Melsheimer.

1844. *Aphodius stercorosus* Melsheimer, Proc. Acad. Nat. Sci. Phila., ii, p. 136.

Specimens examined: 25, from South Bend, Lincoln, West Point and Fairmont, collected from June to August. This species occurs generally east of the Mississippi River.

**Aphodius concavus** Say.

1823. *Aphodius concavus* Say, Journ. Acad. Nat. Sci. Phila., iii, p. 214. Le Conte ed., ii, p. 138.

Specimens examined: 112, from Nebraska City, Lincoln, Hooper, and Hat Creek valley in Sioux Co., collected from April 26 to July 17. All but three of the above noted specimens were taken at Lincoln where they occur commonly at lights during the season indicated. The writer has also taken them in some numbers late in the afternoon on freshly cultivated ground, but has never seen specimens about the droppings of animals.

**Aphodius coloradensis** Horn.

1870. *Aphodius coloradensis* Horn, Trans. Amer. Ent. Soc., iii, pp. 126, 130.

Specimens examined: 4 ♂, 1 ♀, from Mitchell and Lincoln, taken from May 19 to June 17. This species probably occurs not infrequently in western Nebraska, but its occurrence in any numbers in the eastern part of the state is not to be expected.

**Aphodius bicolor** Say.

1823. *Aphodius bicolor* Say, Journ. Acad. Nat. Sci. Phila., iii, p. 212. Le Conte ed., ii, p. 136.

Specimens examined: 1, ♀ from Lincoln, collected October 24, 1915 by C. E. Mickel. Although a widely distributed species occurring from "Canada to Texas and east to Massachusetts," *bicolor* is apparently uncommon in Nebraska.

**Aphodius serval** Say.

1835. *Aphodius serval* Say, Boston Journ. Nat. Hist., i, pp. 177-178. Le Conte ed., ii, p. 651.

Specimens examined: 1 ♀, from Lincoln, collected December 6, 1915, by C. E. Mickel.

**Aphodius distinctus** Mueller.

1776. *Scarabaeus distinctus* Mueller, Zoologiae Danicae prodromus, p. 53.

Specimens examined: 164, from South Bend, Lincoln, Omaha, West Point, Fairmont, Elm Creek, Holt Co., Halsey, and Scottsbluff, collected from March 10 to November 19. This cosmopolitan species is perhaps our most abundant *Aphodius,* occurring at times in immense numbers. It has long been known under the name *inquinatus.*

[**Aphodius subtruncatus** Le Conte.

1878. *Aphodius subtruncatus* Le Conte, U. S. Geol. Serv., Bull., iv, pt. 2, p. 457.

*Subtruncatus* is not represented in the material studied, but is listed here on the authority of Dr. Horn who records it in his monograph of Aphodius (1887) from Colorado and Nebraska.]

**Aphodius walshi** Horn.

1870. *Aphodius walshii* Horn, Trans. Amer. Ent. Soc., iii, pp. 131, 132.

Specimens examined: 28 ♂, 13 ♀, from West Point, Halsey and Mitchell, collected during May and June. *Walshi* is a common species in central Nebraska on sandy soil. Professor Brunner reported it as "fairly swarming" at Halsey, May 17, 1912. This species properly belongs in that section of the genus with pubescent elytra, but it has been run out a second time in the table to take care of those specimens on which the inconspicuous, deciduous pubescence has been lost.

**Aphodius femoralis** Say.

1823. *Aphodius femoralis* Say, Journ. Acad. Nat. Sci. Phila., iii, pp. 215-216. Le Conte ed., ii, p. 139.

Specimens examined: 106, from Fort Calhoun, Omaha, South Bend, Ashland, Cedar Bluffs, Peru, Lincoln, West Point, and Bradshaw, collected from March 2 to September 19.

**Aphodius oblongus** Say.

1823. *Aphodius oblongus* Say, Journ. Acad. Nat. Sci. Phila., iii, p. 215. Le Conte ed, ii, p. 138.

Specimens examined: 1 ♂, taken at Lincoln in March. The known distribution of this species is from Pennsylvania to Colorado and Arizona.

**Ataenius** Harold

1867. Harold: Col. Hefte, ii, p. 100.

1871. Horn: "Synopsis of Aphodiini of the United States", Trans. Amer. Ent. Soc., iii, pp. 284-297. (Descriptive notes for 15 species).

1875. Horn: "Synonymical Notes and Descriptions of New Species of North American Coleoptera", Trans. Amer. Ent. Soc., v, pp. 126–156. (Synonymy of the species described by Harold in Coleopterologische Hefte, xii, 1874).

1887. Horn: "A Monograph of the Aphodiini Inhabiting the United States", Trans. Amer. Ent. Soc., xiv, pp. 1-110. (Table and full descriptions for 26 species).

1910. Blatchley: Coleoptera of Indiana, pp. 924-927. (Descriptive notes and table for 9 species).

One character used in the subjoined table of species probably needs a word of explanation. This is the "accessory spinule," a prolongation of the apical margin of the middle and hind tibiae on the under side adjacent to the spurs. The little spinule is scarcely or not longer than the fimbriae of the apical margin, but is easily distinguished from these by its being distinctly thicker, stronger and not articulated at the base.

SYNOPSIS OF THE SPECIES

1. Clypeus subangulate, sometimes denticulate on each side of the median emargination ..... *abditus*

   Clypeus feebly emarginate, the angles at each side broadly rounded ..... 2

2. Opaque species; pronotum without basal marginal line; head densely, finely punctured, not rugose; elytral intervals each with a row of fine punctures bearing a small, scale-like, yellowish hair ..... *imbricatus*

   Shining species; pronotum with basal marginal line..... 3

3. Hind tibiae without accessory spinule, form slender and elongate ..... *gracilis*

   Hind tibiae with accessory spinule..... 4

4. Intervals of elytra very flat, densely and rather coarsely punctured; form short and robust..... *robustus*

   Intervals of elytra convex, rarely punctate..... 5

5. Clypeus finely punctured, without traces of wrinkles; occiput with coarse punctures; hind femora with a deep marginal line extending two-thirds to the base..... *strigatus*

   Clypeus transversely wrinkled or coarsely punctured; hind femora with at most a fine and feeble marginal line near the knee ..... *cognatus*

**Ataenius abditus** Haldeman.

1848. *Aphodius abditus* Haldeman, Journ. Acad. Nat. Sci. Phila., p. 106.

Specimens examined: 45, from Lincoln, Weeping Water and West Point, collected from April to June. *Abditus* is a common and very widely distributed species, occurring from Massachusetts to California and South America.

**Ataenius imbricatus** Melsheimer.

1844. *Aphodius imbricatus* Melsheimer, Proc. Acad. Nat. Sci. Phila., ii, p. 136.

Specimens examined: 3, one from Holt Co., and two from Halsey, collected July 5, 1908 by F. H. Shoemaker. This species occurs from Massachusetts to Texas, but is less common than the preceding one.

**Ataenius gracilis** Melsheimer.

1844. *Oxyomus gracilis* Melsheimer, Proc. Acad. Nat. Sci. Phila., ii, p. 137.

Specimens examined: 1, from Plattsmouth. This is a very distinct, common and widely distributed species which should be better represented in the collection.

**Ataenius robustus** Horn.

1871. *Ataenius robustus* Horn, Trans. Amer. Ent. Soc., iii, pp. 284, 285-286.

Specimens examined: 3 ♂, 5 ♀, from Lincoln, Fairmont and West Point, collected in April and July.

[**Ataenius strigatus** Say.

1823. *Aphodius strigatus* Say, Journ. Acad. Nat. Sci. Phila., iii, p. 212. Le Conte ed., ii, p. 137.

No specimens of *strigatus* have been taken in Nebraska, but it almost certainly occurs in the state, since it is recorded from Iowa, and the "Middle States" to the Rocky Mountain region.]

**Ataenius cognatus** Le Conte.

1858. *Euparia cognata* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 65.

Specimens examined: 50 ♂, 97 ♀, from Fort Calhoun. Omaha, Weeping Water, South Bend, Lincoln, Fairmont, West Point, and Halsey, collected from March to September. This is our most abundant species and is often seen flying in countless numbers on a warm evening in early spring.

**Psammobius Heer**

1841. Heer: Fauna Coleopterorum helvetica, Turici, p. 531.

1871. Horn: "Synopsis of Aphodiini of the United States", Trans. Amer. Ent. Soc., iii, 284-297. (Descriptive notes and table for 5 species).

1887. Horn: "A Monograph of the Aphodiini Inhabiting the United States", Trans. Amer. Ent. Soc., xiv, pp. 1-110. (Descriptive notes and table for 7 species).

1910. Blatchley: Coleoptera of Indiana, p. 922. (Descriptive notes for 2 species).

**Psammobius interruptus** Say.

1835. *Psammodius interruptus* Say, Boston Journ. Nat. Hist., i, p. 178. Le Conte ed., ii, pp. 651-652.

Specimens examined: 5, from West Point, collected in May and June. This species is recorded by Dr. Horn as uncommon in the middle states.

**Rhyssemus** Mulsant

1842. Mulsant: Hist. nat. d. Col. de France, Lyon, ii, Lamellicornes, p. 314.

1871. Horn: "Synopsis of Aphodiini of the United States", Trans. Amer. Ent. Soc., iii, pp. 284-297. (Descriptive notes on three species).

1887. Horn: "A Monograph of the Aphodiini Inhabiting the United States", Trans. Amer. Ent. Soc., xiv, pp. 1-110. (Descriptive notes and table for 4 species).

SYNOPSIS OF THE SPECIES

1. Clypeus angulate or subangulate on each side; intervals of elytra with a double row of nearly equal tubercles.....*sonatus*

   Clypeus obtuse or rounded on each side of the emargination; intervals of elytra with a row of small tubercles on the inner side, a continuous, finely elevated line on the outer side.....[*scaber*]

**Rhyssemus sonatus** Le Conte.

1881. *Rhyssemus sonatus* Le Conte, Trans. Kansas Acad. Sci., x, p. 77.

Specimens examined: 6, from Lincoln, collected in April, June and July. *Sonatus* is also recorded from Iowa, Kansas, Colorado and Montana.

[**Rhyssemus scaber** Haldeman.

1848. *Rhyssemus scaber* Haldeman, Journ. Acad. Nat. Sci. Phila., p. 107.

No specimens of this species are at hand from Nebraska, but judging from Dr. Horn's statement, "occurs at the margins of streams from the Middle States to Texas," it is to be expected in the state.]

ORPHNINI

Oval, convex species, brown or dull yellow in color covered above with short, erect hair; elytra striate; clypeus not expanded as in the two preceding tribes, and mandibles and labrum visible; principally western in range.

**Ochodaeus** Serville

Little is known of the habits of the species in this genus, and they are seldom seen except at lights in the evening.

1825. Serville: Entomological part of Encyclopédie methodique, x, p. 360.

1868. Le Conte: "New Coleoptera Collected on the Survey for the Extension of the Union Pacific Railway, E. D. from Kansas

to Fort Craig, New Mexico", Trans. Amer. Ent. Soc., ii, pp. 49–59. (Notes and table for 10 species).

1876. Horn: "Revision of the United States Species of Ochodaeus and other Genera of Scarabaeidae", Trans. Amer. Ent. Soc., v, pp. 179-197. (Descriptive notes and table for 8 species).

1909. Fall: "A Short Synopsis of the Species of Ochodaeus Inhabiting the United States", Journ. N. Y. Ent. Soc., xvii, pp. 30-38. (Descriptive notes and table to 19 species).

SYNOPSIS OF THE SPECIES

1. Front with an acute horn or tubercle.....*mandibularis*

   Front without an acute tubercle..... 2

2. Apical angles of elytra slightly produced or dentiform; upper tooth of front tibiae nearer to the middle tooth than to the base ..... 3

   Apical angles of elytra not at all produced.....*musculus*

3. Vertex of male with a transverse ridge; frontal margin not acutely tuberculate .....*kansanus*

   Vertex of male without a transverse ridge; frontal margin elevated on each side into a small tubercle.....[*biarmatus*]

**Ochodaeus musculus** Say.

1835. *Odontaeus musculus* Say, Boston Journ. Nat. Hist., i, p. 178. Le Conte ed., ii, p. 51.

1910. *Ochodaeus musculus* Blatchley, Coleoptera of Indiana, p. 935.

Specimens examined: 1♂, 5♀, from Mitchell and Monroe Canyon in Sioux Co., collected during July at lights. *Musculus* is probably not confined to western Nebraska even though there are no specimens at hand from other parts of the state.

**Ochodaeus kansanus** Fall.

1909. *Ochodaeus kansanus* Fall, Journ. N. Y. Ent. Soc., xvii, pp. 31, 34.

Specimens examined: 1♂, 2♀, from Mitchell, taken at lights July 24-29, 1916, by C. E. Mickel.

[**Ochodaeus biarmatus** Le Conte.

1868. *Ochodaeus biarmatus* Le Conte, Trans. Amer. Ent. Soc., ii, p. 51.

This species has not been taken in Nebraska. However, it is common from Kansas southward and may be found in the southwestern part of the state.]

**Ochodaeus mandibularis** Linell.

1896. *Ochodaeus mandibularis* Linell, Proc. U. S. Nat. Mus., xviii, p. 723.

Specimens examined: 1, from Mitchell, taken at light, July 24, 1916 by C. E. Mickel.

GEOTRUPINI

Body rounded and very convex, elytra usually strongly striate; pronotum of the male frequently modified, armed with horns or tubercles; head of male sometimes armed; mandibles and labrum prominent; antennae 11-jointed; pygidium always entirely covered by the elytra.

**Odontaeus** Klug

1843. Klug: Abhandl, d. K. Akad. d. Wiss. z. Berlin, p. 37.

1870. Horn: "Notes on some Genera of Coprophagus Scarabasidae of the United States", Trans. Amer. Ent. Soc., iii, pp. 42-51. (Descriptive notes on 3 species).

1910. Blatchley: Coleoptera of Indiana, p. 938. (Descriptive notes on 2 species).

Thus far none of the three species known in this genus have been collected in Nebraska, but judging from the recorded distribution of *cornigerus* Melsheimer and *filicornis* Say both are likely to occur in the state. In the former species the clypeal horn of the male is stout and fixed, while in the latter it is slenderer and movable.

**Bolbocerosoma** Schaeffer

1906. Schaeffer: Trans. Amer. Ent. Soc., xxxii, pp. 250, 254.

1923. Dawson and McColloch: Can. Ent. lv. pp.

SYNOPSIS OF THE SPECIES

1. Sutural interval and a rather large, slightly postmedian spot, black, remainder of elytra reddish brown.....*biplagiatum*

   Sutural interval of elytra and terminal half largely or entirely black ..... 2

2. Smaller, length about 7 mm.; second elytral stria obsolete, fifth but feebly indicated, thus leaving six relatively broader dorsal interspaces to the humeri.....[*pusillum*]

   Larger, length 9 – 12 mm.; second and fifth elytral striae strong and deep like the others, thus making eight relatively narrower dorsal interspaces to the humeri.....*bruneri*

**Bolbocerosoma biplagiatum** Dawson and McColloch.

1923. *Bolbocerosoma biplagiatum* Dawson and McColloch, Can. Ent. lv. p.

Specimens examined: 1 ♂, from Oxford, collected June 4, 1918. This species is not uncommon in Kansas.

[**Bolbocerosoma pusillum** Dawson and McColloch.

1923. *Bolbocerosoma pusillum* Dawson and McColloch, Can. Ent. lv. p.

No specimens of this species are at hand from Nebraska, but it occurs frequently at Manhattan, Kansas, and may therefore be found in southern Nebraska, especially in the valley of the Republican river.]

**Bolbocerosoma bruneri** Dawson and McColloch.

1923. *Bolbocerosoma bruneri* Dawson and McColloch, Can. Ent. lv. p.

Specimens examined: 15 ♂, 15 ♀, from Maskell, Rulo, Louisville, Omaha, Lincoln, Fairmont, Carns, Humphrey, and Sowbelly Canyon in Sioux Co., collected from April to October.

**Eucanthus** Westwood

Only one species from the North American fauna has been referred to this genus.

1852. Westwood: Trans. Linn. Soc. Lond., xxi, p. 26.

**Eucanthus lazarus** Fabricius.

1775. *Scarabaeus lazarus* Fabricius, Systema Entomologiae, p. 11.

1870. *Bolboceras lazarus* Horn, Trans. Amer. Ent. Soc., iii, p. 49.

1906. *Bolboceras lazarus* Schaeffer, Trans. Amer. Ent. Soc., xxxii, p. 253.

1910. *Bolboceras lazarus* Blatchley, Coleoptera of Indiana, p. 937.

1910. *Eucanthus lazarus* Boucomont, Ann. Soc. Ent. France, lxxix, p. 336.

Specimens examined: 54 ♂, 70 ♀, from Nebraska City, South Sioux City, Omaha, Hooper, Fremont, Norfolk, Lincoln, Fairmont, West Point, Neligh, Holt Co., Exeter, Red Cloud, Halsey, Valentine, and Mitchell, collected from May 14 to August 31. *Lazarus* is seldom seen except at lights, but there it is often present in numbers, especially during June and July.

**Geotrupes** Latreille

1796. Latreille. Précis des Caractères générique des Insectes, Bordeaux, p. 6.

1868. Horn: "Geotrupes of Boreal America", Trans. Amer. Ent. Soc., i, pp. 313-322.

1880. Horn: "Contributions to the Coleopterology of the United States, No. 3", Trans. Amer. Ent. Soc., viii, p. 139-154. (Table for 9 species).

1888. Blanchard: "Some Account of our Species of Geotrupes", Psyche, v, pp. 103-110. (Descriptive notes and table).

1910. Blatchley: Coleoptera of Indiana, pp. 938-939. (Descriptive notes and table for 4 species).

SYNOPSIS OF THE SPECIES

1. Body above shining, more or less metallic; elytra distinctly striate ..... 2

   Body above opaque, black; elytra not striate, but with rows of punctures ..... *opacus*

2. Striae of elytra without punctures; head without tubercles; basal marginal line of pronotum more or less incomplete medially ..... *semiopacus*

   Striae of elytra punctured; head with a median tubercle; basal marginal line of pronotum entire ..... *splendidus*

**Geotrupes opacus** Haldeman.

1853. *Geotrupes opacus* Haldeman, Proc. Acad. Nat. Sci. Phila., p. 362.

Specimens examined: 16 ♂, 26 ♀, from Omaha, Ashland, Lincoln, West Point, Holt Co., Halsey and Haigler.

**Geotrupes semiopacus** Jekel.

1865. *Geotrupes semiopacus* Jekel, Ann. Soc. Ent. France, (4) v, p. 612.

Specimens examined: 1 ♂, collected at Omaha in September, 1888.

**Geotrupes splendidus** Fabricius.

1775. *Scarabaeus splendidus* Fabricius, Systema Entomologiae, p. 18.

Specimens examined: 15 ♂, 19 ♀, from Maskell, Omaha, Weeping Water, Nebraska City, Lincoln and West Point.

The following note on the habits of this species seems worthy of record. During the month of June, 1905, while the writer was spading in his home garden he had occasion to remove a quantity of lawn clippings that had been piled on a bare spot of ground several weeks previously. In turning up the soil that had been covered by the clippings a rather large and neatly formed pod of dead grass was discovered, and along with it a female *splendidus*. Careful examination disclosed a branched tunnel with four additional food pods. One of the pods was preserved, and is before me at the present

writing, the others were placed in a box of moist soil, from which the beetles emerged the following August. The food pods were all pear-shaped, and very uniform in size, measuring about two inches in length by one inch in their greatest diameter. The pods are interesting because of their relatively large size, and from being composed entirely of clean, fresh grass blades. A greater bulk of clean food seems to be required than is the case with the more concentrated material (droppings of animals) most freqently used by the beetles in this section of the family *Scarabaeidae.*

### Glaphyrini

Form oblong, not convex; remarkable for the long hairs on the legs and under surface; head and pronotum also, usually densely covered with long hairs; elytra spreading apart to the tips and pygidium exposed; adults frequenting flowers.

#### **Amphicoma** Latreille

1807. Latreille: Genera Crustaceorum et Insectorum, ii, p. 118.

1861. Horn: "Descriptions of New Genera and Species of Western Scarabaeidae, with Notes on Others Already Known", Trans. Amer. Ent. Soc., i, pp. 163-170. (Characterization of 2 species).

1882. Horn: "Notes on Some Little Known Genera and Species of Coleoptera", Trans. Amer. Ent. Soc., x, pp. 113-126.

1901. Fall: "Coleoptera of Southern California", Calif. Acad. Sci., pp. 139, 255. (List of species and descriptive notes).

**Amphicoma vulpina** Hentz.

1826. *Amphicoma vulpina* Hentz, Journ. Acad. Nat. Sci. Phila., v, p. 374, pl. 13, fig. 3.

Specimens examined: 1, from Dismal River in July.

TROGINI

Oblong, convex species, surface of body dull and roughened; living in dried decomposing animal matter; mandibles and labrum prominent; epimera of the mesothorax widely separated from the coxae by the sternum; abdomen with five ventral segments, amply covered by the elytra; terminal segment of the tarsus without erect setae between the claws.

**Glaresis** Erichson

1848. Erichson: Naturgeschichte der Insecten Deutschlands, vi, p. 925.

1885. Horn: "Descriptions of New North American Scarabaeidae", Trans. Amer. Ent. Soc., xii, pp. 117-128. (Descriptive notes on 3 species).

1907. Fall: "The North American Species of Glaresis", Psyche, xiv, pp. 23-26. (Descriptive notes and table for 4 species).

**Glaresis phoenicis** Fall.

1907. *Glaresis phoenicis* Fall, Psyche, xiv, pp. 24-26.

Specimens examined: 1, from Mitchell, June 29, 1916, collected by C. E. Mickel.

**Trox** Fabricius

The species of this genus are all carrion feeders, preferring this material after it is well rotted and dried. Many of the species are attracted in some numbers to lights at night. Whether collected at lights or in carrion the specimens are usually well encrusted with dirt and should be cleaned before mounting. This is easily done by holding them under running water and brushing with a camel's hair brush. It is highly probable that a renewed study of the genus *Trox* employing the characters to be found in the genitalia will somewhat modify our present understanding of the species and varieties, especially the latter.

1775. Fabricius: Systema Entomologiae, p. 31.

1854. Le Conte: "Descriptions of the Species of Trox and Omorgus Inhabiting the United States", Proc. Acad. Nat. Sci. Phila., vii, pp. 211-216.

1874. Horn: "Revision of the Species of *Trox* of the United States", Trans. Amer. Ent. Soc.,v, pp. 1-12. Descriptive notes and table for 21 species).

1910. Blatchley: Coleoptera of Indiana, pp. 941-947. (Descriptive notes and table for 15 species).

1922. Loomis: "New Species of the Coleopterous Genus Trox", Journ. Wash. Acad. Sci., xii, pp. 132-136. (Characterizes 3 forms from the southwest in the *scutellaris* section of the genus, and points out the specific value of the characters in the male genitalia).

SYNOPSIS OF THE SPECIES

1. Scutellum strongly narrowed near the base, with the sides angulate at the middle; sides of pronotum never margined with scales or stiff hairs ..... 2

   Scutellum not narrowed at the base, the sides not angulate, but curved; sides of pronotum often margined with scales or hairs ..... 6

2. Base of elytra distinctly narrowed, with the humeral angles very broadly and strongly rounded ..... [*scutellaris*]

   Base of elytra not more strongly narrowed and rounded than usual ..... 3

3. Elytra with rows of very distinct tubercles ..... 4

   Elytra with rows of feebly elevated, bare tubercles connected by elongate, tomentose spots ..... *suberosus*

4. Tubercles prominent, bare and shining, with tomentose spots behind them ..... *punctatus*

   Tubercles at least on the posterior side tomentose ..... 5

5. Tubercles large and coarse, bare and shining anteriorly, and tomentose behind; first joint of antennae with dark brown hairs; antennal club dark ..... *scabrosus*

Tubercles much smaller, and more nearly covered with tomentum; first joint of antennae with rufous hairs; antennal club rufous or cinereous ..... *asper*

6. Elytral intervals with continuous, single rows of short, erect, scale-like hairs; prosternum usually produced into a spine behind the anterior coxae ..... *atrox*

Elytral intervals without continuous, single rows of short, erect scales ..... 7

7. Larger species, length 8 – 12 mm. ..... 8

Smaller species, length 5 – 7 mm. ..... 10

8. Lateral margins of elytra serrated or roughened, especially toward the base ..... 9

Lateral margins of elytra even or continuous, not serrated; scales of elytral striae arranged in double rows, more or less continuous basally especially on the first stria, elsewhere more or less interrupted ..... *unistriatus*

9. Median, longitudinal sulcus of pronotum usually entire, at most feebly interrupted by a transverse ridge, sides of the sulcus nearly straight; elytral tubercles with semi-erect, brownish scales ..... *tuberculatus*

Median, longitudinal sulcus of pronotum more or less interrupted medially by the narrowing of the sides and a feebly elevated, transverse ridge; elytral tubercles with semi-recumbent, yellowish scales ..... *sonorae*

10. Discal area of pronotum not, or only slightly sulcate or impressed ..... 11

Discal area of pronotum with four large, shallow impressions ..... *insularis*

11. Elytral intervals more or less convex, with the scales arranged in short, longitudinal, double rows ..... 12

Elytra black, shining, the intervals nearly flat, with very feeble transverse elevations, each bearing a transverse row of two or three short, erect, brownish hairs or scales ..... *laticollis*

12. Anterior tibiae above the lateral tooth serrulate; alternate intervals of elytra more prominent, and with the pubescent spots more elongated ..... *scaber*

Anterior tibiae above the lateral tooth simple, alternate intervals of elytra not differing noticeably from the others.....*aequalis*

[**Trox scutellaris** Say.

1824. *Trox scutellaris* Say, Journ. Acad. Nat. Sci. Phila., iii, pp. 238-239. Le Conte ed., ii, p. 140.

No specimens of *scutellaris* are at hand from Nebraska, but it is probable that a little careful collecting in the southwestern part of the state would reveal its presence. Since it is a wingless species it is not likely to be found except at carrion. The recorded distribution of the species is from Kansas to Mexico.]

**Trox scabrosus** Beauvois.

1805. *Trox scabrosus* Beauvois, Insectes recueillis en Afrique et en Amérique, p. 175, pl. 4b. fig. 4.

Specimens examined: 10, from Holt Co., Cherry Co., and the Sand Hills. This is the largest species of Trox, except *scutellaris,* to be expected in the Nebraska fauna. It measures 15-18 mm. in length.

**Trox asper** Le Conte.

1854. *Trox asper* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 215.

Specimens examined: 3, two of which are labelled "Nebraska," and the other one "Lincoln, June, At light."

**Trox suberosus** Fabricius.

1798. *Trox suberosus* Fabricius, Systema Entomologiae, p. 31.

Specimens examined: 82, from Nebraska City, Omaha, South Bend, Lincoln, West Point, Fairmont, Minden, Pine Ridge, and Big Spring, collected from May to August. This is apparently our commonest large *Trox.* It occurs regularly at Lincoln about the electric lights, where 70 of the above listed specimens were taken.

**Trox punctatus** Germar.

1824. *Trox punctatus* Germar, Insectorum species novae, p. 113.

Specimens examined: 11, from McCook, Grant, Mitchell and Harrisburg.

**Trox tuberculatus** De Geer.

1778. *Trox tuberculatus* De Geer, Memoirs pour servir a l' histoire des Insectes, iv, p. 318, pl. 19, fig. 2.

Specimens examined: 25, all taken at Lincoln from April to July 9, at lights.

**Trox sonorae** Le Conte.

1854. *Trox Sonorae* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 211.

Specimens examined: 17, from Lincoln, Harrisburg and the Pine Ridge region of Sioux and Dawes counties, collected from June to August.

**Trox unistriatus** Beauvois.

1805. *Trox unistriatus* Beauvois, Insectes recueillis en Afrique et en Amerique, p. 175, pl. 4 b. fig. 5.

Specimens examined: 25, from Lincoln and "Pine Ridge," collected from April to July.

**Trox insularis** Chevrolat.

1864. *Trox insularis* Chevrolat, Ann. Soc. Ent. France (4) iv, pp. 416-417.

1874. *Trox foveicollis* Horn, Trans. Amer. Ent. Soc., v, pp. 7, 10.

Specimens examined: 5, from Lincoln and West Point, taken during April and May.

**Trox aequalis** Say.

1832. *Trox aequalis* Say, New Species of Insects from Louisiana, p. 5. Le Conte ed., i, p. 301.

Specimens examined: 9, from Lincoln, collected from April to June.

**Trox scaber** Linnaeus.

1767. *Trox scaber* Linnaeus, Systema Naturae, ed. xii, p. 573.

Specimens examined: 2, from Lincoln and Fairmont, collected in July.

**Trox atrox** Le Conte.

1854. *Trox atrox* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 214.

Specimens examined: 24, from Lincoln, Fremont, and Monroe Canyon, collected from April to July.

**Trox laticollis** Le Conte.

1854. *Trox laticollis* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 213.

Specimens examined: 1, taken at Lincoln in June.

## MELOLONTHINAE

Abdominal spiracles in part situated on the upper portions of the sternites, the last one usually visible behind the elytra; the rows of spiracles feebly diverging; ligulae usually firmly united with the mentum; the species feeding upon living vegetable matter.

### Sericini

Posterior coxae flat and broadly dilated; elytra more or less distinctly sulcate; labrum indistinct.

**Serica** Mac Leay

1819. Mac Leay: Horae entomologicae, i, p. 146.

1856. Le Conte: "Synopsis of the Melolonthidae of the United States," Journ. Acad. Nat. Sci. Phila., (2) iii, pp. 225-288. (Descriptive notes and table for 15 species).

1897-1902. Brenske: "Die Serica Arten der Erde," Berliner Entomol. Zeitschr, xlii, (Table of related genera), xlvii, (List of names in the genus for the world).

1910. Blatchley: Coleoptera of Indiana, pp. 956-958. (Descriptive notes and table for 7 species).

1919-1922. Dawson: "New Species of Serica," parts 1-5, Journ. N. Y. Ent. Soc., xxvii-xxx. (Descriptions and figures of 28 species.)

SYNOPSIS OF THE SPECIES

1. Surface of elytra bare, polished and shining ..... 5

   Surface of elytra more or less opaque, often with a more or less distinct, iridescent bloom ..... 2

2. Surface very opaque, in fresh, clean specimens velvety and showing a brilliant, iridescent sheen of rainbow colors when held at varying angles to the light ..... 3

   Surface semi-opaque, not velvety, and without brilliant iridescence ..... 4

3. Clypeus (viewed from the side) uniformly and rather closely covered with erect, brown hairs; surface lustre of pronotum similar in the male and female ..... *mystaca*

   Clypeus with only a few erect hairs anteriorly; surface of prontum more or less distinctly polished and shining in the female, and oqaque in the male ..... *sericea*

4. Pallid, yellowish brown in color with little or no iridescence, form more elongate and slender ..... *curvata*

   Dark brown to blackish, often with a distinct purplish sheen; form rather short and robust ..... *anthracina*

5. Color yellowish brown or ochraceous; notch between apical and lateral reflexed margins of clypeus deep, relatively broad, and and rounded at the bottom ..... *ochrosoma*

   Color varying from chestnut to a very dark reddish brown; clypeal notch less strongly developed, narrower and often acute at the bottom ..... 6

6. Clypeus and mid-lateral areas of pronotum rather finely and very densely punctured, the punctures separated by less than half their own diameters; sutural margin and median line of front distinctly keeled or elevated ..... *evidens*

   Clypeus and pronotum more coarsely and less densely punctured, the punctures of the pronotum rather evenly distributed from side to side; sutural margin of front feebly, or not at all, carinated, raised median line of front usually obsolete ..... 7

7. Claspers of male genital armature similar in shape and size ..... *intermixta*

Claspers of male genital armature distinctly dissimilar in size and shape ..... 8

8. Color always chestnut; stalk of male genital armature nearly symmetrical .....*vespertina accola*

Color varying from chestnut to a very dark reddish brown; stalk of male genital armature distinctly shorter on the right side .....*campestris*

**Serica vespertina accola** Dawson.

1921. *Serica vespertina accola* Dawson, Journ. N. Y. Ent. Soc., xxix, pp. 164-165, pl. xii.

Specimens examined: 4 ♂, 8 ♀, from Lincoln, South Bend and West Point, collected during May and June.

**Serica evidens** Blatchley.

1910. *Serica carinata* Blatchley, Coleoptera of Indiana, pp. 956, 957.
1919. *Serica evidens* Blatchley, Can. Ent., xiii, p. 153. (New name).

Specimens examined: 4 ♀, from Nebraska City and Omaha, collected during April and May. This species also occurs in Illinois and Kansas as well as Indiana from which state it was originally described.

**Serica intermixta** Blatchley.

1910. *Serica intermixta* Blatchley, Coleoptera of Indiana, pp. 956, 957.

Specimens examined: 11 ♂, 3 ♀, from Hooper, South Bend, West Point, Neligh and Monroe Canyon in Sioux Co. *Intermixta* is one of the commoner and more widely distributed species of the genus. It is essentially northern in range, occurring abundantly throughout Canadian territory.

**Serica campestris** Dawson.

1919. *Serica campestris* Dawson, Journ. N. Y. Ent. Soc., xxvii, pp. 33-34, pl. vi.

Specimens examined: 41 ♂, 19 ♀, from Lincoln, Fairmont, Hooper and Brock, collected from March 28 to July

8, most of the specimens coming from Lincoln where they were taken at lights. This species also occurs in Kansas, Iowa, Illinois and Indiana.

**Serica ochrosoma** Dawson.

1919. *Serica ochrosoma* Dawson, Journ. N. Y. Ent. Soc., xxvii, pp. 38-39, pl. ix.

Specimens examined: 7 ♂, 1 ♀, from Halsey and Holt Co., collected in early June at lights. While possibly locally common, this species is rarely represented in the collections of the country.

**Serica sericea** Illiger.

1802. *Melolontha sericea* Illiger, Olivier's Entomologie, ii, part 5, p. 75, footnote A.

1922. *Serica sericea* Dawson, Journ. N. Y. Ent. Soc., xxx, pp. 154-156, pl. xi.

Specimens examined: 21 ♂, 27 ♀, from Omaha, Nebraska City, Ashland, South Bend, Hooper, Lincoln, West Point, Halsey, Monroe and Warbonnet Canyons in Sioux Co., collected from April 29 to August 2.

**Serica mystaca** Dawson.

1922. *Serica mystaca* Dawson, Journ. N. Y. Ent. Soc. xxx, pp. 160-161, pl. xiv.

Specimens examined: 1 ♂, collected at Nebraska City, April 29, 1916, under leaves. *Mystaca* is a widely distributed species, being recorded from eighteen states, but is apparently not common anywhere in its known range.

**Serica curvata** Le Conte.

1856. *Seriva curvata* Le Conte, Journ. Acad. Nat. Sci. Phila., (2) iii, p. 276.

1922. *Serica curvata* Dawson, Journ. N. Y. Ent. Soc., xxx, pp. 167-169, pl. xxiii.

Specimens examined: 13 ♂, from the Pine Ridge Re-

gion of Sioux and Dawes counties, collected at lights from June 23 to July 23. It is probable that *curvata* does not occur in Nebraska much to the south and east of the Pine Ridge Region in the northwestern part of the state.

**Serica anthracina** Le Conte.

1856. *Serica anthracina* Le Conte, Journ. Acad. Nat. Sci. Phila., (2) iii, p. 276.

1856. *Serica frontalis* Le Conte, Ibid. p. 276.

1856. *Serica robusta* Le Conte, Ibid. p. 276.

1869. *Serica valida* Harold, Col. Hefte, v, p. 123.

Specimens examined: 3 ♂, 1 ♀, from Mitchell and the Pine Ridge region, collected during June and July. This species, like the preceding, is a western form which probably does not extend its range far into the state. It is widely distributed in the Rocky Mountain and Pacific regions, and is highly variable in size and color. The writer has examined the Le Conte types and is responsible for the above cited synonymy. The name *valida* was merely a new name to replace *robusta* which was preoccupied.

MELOLONTHINI

Middle and hind tibiae with two spurs; last segment of tarsi with two erect setae between the claws; tarsal claws equal; last spiracle placed on the nearly obsolete suture between the fifth sternite and the propygidium.

**Diplotaxis** Kirby

1837. Kirby: Fauna Boreali-Americana, iv, p. 129.

1856. Le Conte: "Synopsis of the Melolonthidae of the United States," Journ. Acad. Nat. Sci. Phila., (2) iii, pp. 225-288. (Descriptive notes on 29 species.)

1909. Fall: "Revision of the Species of Diplotaxis of the United States," Trans. Amer. Ent. Soc., xxxv, pp. 1-97. (Descriptive notes and table for 95 species.)

SYNOPSIS OF THE SPECIES

1. Posterior margin of pronotum depressed below the level of the adjacent surface ..... 7

   Posterior margin of pronotum not depressed..... 2

2. Hind angles of pronotum distinctly, usually rather strongly impressed ..... 6

   Hind angles of pronotum feebly or not at all impressed..... 3

3. Pronotum viewed from above very distinctly wider just behind the middle than at the base, the side margins very strongly arcuate .....*subangulata californica*

   Pronotum viewed from above but little if any wider near the middle than at the base, the side margins much less strongly arcuate ..... 4

4. Size smaller, 6-10 mm. in length; western species..... 5

   Size larger, 10-14 mm. in length; eastern species.....*tristis*

5. Clypeal margin rounded, feebly or just perceptibly emarginate at the middle; length 6-8 mm.....*carbonata*

   Clypeal margin subtruncate, moderately emarginate at the middle; length 8-10 mm.....*tenebrosa*

6. Anterior angles of pronotum obtuse, distinctly impressed, color averaging darker, rufo-testaceous to nearly black.....*obscura*

   Anterior angles of pronotum acute, feebly impressed, color lighter, rufo-testaceous .....*haydeni*

7. Depressed basal zone of pronotum relatively wide and complete from side to side..... 8

   Depressed basal zone of pronotum much narrower, nearly or quite obsolete at the middle.....*frondicola*

8. Clypeal margin almost evenly accurate from side to side, less strongly reflexed; head relatively wider.....*harperi*

   Clypeal margin subtruncate, often slightly emarginate at the middle, more strongly reflexed; head relatively narrower.....*basalis*

**Diplotaxis tenebrosa** Fall.

1909. *Diplotaxis tenebrosa* Fall, Trans. Amer. Ent. Soc., xxxv, pp. 13, 35-36.

No specimens of this species are at hand from Nebraska, but Mr. Fall records in his monograph a single specimen in the Bowditch collection labelled "Nebraska". Since *tenebrosa* is a fairly common species in the northwestern states one might reasonably expect to collect it in the Pine Ridge region of western Nebraska.

**Diplotaxis haydeni** Le Conte.

1856. *Diplotaxis haydeni* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iii, p. 272.

1856. *Diplotaxis innoxia* Le Conte, Ibid., p. 273.

Specimens examined: 88, from Cedar Bluffs, Dewey Lake in Cherry Co., North Platte, Haigler, Harrisburg, and the Pine Ridge region in Sioux Co., collected from April to August 1.

**Diplotaxis obscura** Le Conte.

1859. *Diplotaxis obscura* Le Conte, Coleopetra of Kansas and New Mexico, p. 9.

Specimens examined: 1, from Sioux County. Examples are also at hand from Custer, South Dakota and Newcastle, Wyoming. The species was described from the Black Hills, and is rather widely distributed in the Rocky Mountain Region.

**Diplotaxis tristis** Kirby.

1837. *Diplotaxis tristis* Kirby, Fauna Boreali-Americana, iv, p. 130.

Specimens examined: 3, from Lincoln, collected in latter May. *Tristis* is an eastern species scarcely to be expected this far west, but it has also been recorded from Kansas. The three specimens at hand are all small, (10 – 12 mm.) for the species which in the larger examples attains a length of 14 mm.

**Diplotaxis subangulata californica** Schaeffer.

1907. *Diplotaxis californica* Schaeffer, Journ. N. Y. Ent. Soc. xv, p. 66.

Specimens examined: 1, from Mitchell, Scottsbluff County, collected August 1, 1917 by E. J. Yates. This form, or as here listed subspecies, is probably not uncommon in western Nebraska, since it occurs rather abundantly all through the western states.

**Diplotaxis carbonata** Le Conte.

1856. *Diplotaxis carbonata* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iii, p. 270.

No specimens of this species are at hand. However, Mr. Fall records a specimen from Fort Robinson, Nebraska, and says that *carbonata* occurs southward to Arizona, being rather common in Colorado and New Mexico.

**Diplotaxis frondicola** Say.

1825. *Melolontha frondicola* Say, Journ. Acad. Nat. Sci. Phila., v, p. 198.

Specimens examined: 76, from Lincoln, South Bend, West Point and Carns, collected from May 11, to August 29. About a third of the specimens were collected at night feeding on oak leaves.

**Diplotaxis basalis** Fall.

1909. *Diplotaxis basalis* Fall, Trans. Amer. Ent. Soc., xxxv, pp. 19, 73.

Specimens examined: 85, from Dakota City, Hooper, Ashland, Lincoln, Osceola and Fairmont, collected from May 20 to July 25. Seventeen of the above listed specimens were taken at night feeding on elm leaves, and two on oak leaves. Doubtless a very extended series of this and the preceding species could be collected by inspecting foliage after dark with a lantern or a flash light. The other species of the genus here listed could also probably be collected with the greatest facility by this method.

**Diplotaxis harperi** Blanchard.

1850. *Diplotaxis harperi* Blanchard, Cat. de la coll. ent. Coleop. Mus. d'hist. nat. de Paris, p. 171.

Specimens examined: 17, from Omaha, Nebraska City and Lincoln, collected from April 30 to August 29. *Harperi* is an abundant and widely distributed species, especially through the eastern and southern states.

### **Diazus** Le Conte

1859. Le Conte: "Coleoptera of Kansas and New Mexico," Smithsonian Contributions to Knowledge, xi, p. 9.

**Diazus rudis** Le Conte.

1859. *Diazus rudis* Le Conte, Col. Kan. and N. M., p. 9.

Specimens examined: 10, from the Pine Ridge region, Mitchell, Haigler, Culbertson and Halsey, collected from July 3 to 20.

### **Phyllophaga** Harris

The species of this genus are commonly known as "June bugs" or May beetles, and their larvae are called white grubs. Both the beetles and their larvae are highly destructive to cultivated plants. This is more especially true of the larvae which burrow in the soil and feed heavily upon roots. They are difficult to combat, and their long life of two or three seasons renders them especially troublesome. The beetles do some damage as defoliators, collecting upon trees, shrubs and herbaceous plants in considerable numbers at twilight and gorging themselves with food until nearly daybreak, then they disperse and seek shelter, burying themselvs an inch or so in the soil.

1826. Harris: Massachusetts Agricultural Journal and Repository, x, p. 6.

1856. Le Conte: "Synopsis of the Melolonthidae of the United States," Journ. Acad. Nat. Sci. Phila., (2), iii, pp. 225-288. (Descriptive notes on 55 species.)

1887. Horn: "Revision of the Species of Lachnosterna of America North of Mexico," Trans. Amer. Ent. Soc., xiv, pp. 209-296. (Descriptive notes and table for 81 species.)

1888. Smith: "Notes on the Species of Lachnosterna of Temperate North America, with Descriptions of New Species," Proc. U. S. Nat. Mus., xi, pp. 481-525, pls. xlvii-lx. (Descriptive notes and figures of the genitalia of 87 species.)

1910. Blatchley: Coleoptera of Indiana, pp. 958-980. (Descriptive notes, table and figures for 35 species.)

1916. Glasgow: "Phyllophaga Harris (Lachnosterna Hope): A Revision of the Synonymy, and One New Species," Bull. Ill. State Lab. Nat. Hist., xi, pp. 365-379.

1920. Hays and McColloch: "Some Observations on the Genitalia of Lachnosterna," Ann. Ent. Soc. Amer., xiii, pp. 75-82, pl. viii. (Nine species figured and discussed.)

1920. Davis: "New Species and Varieties of Phyllophaga," Ill. Nat. Hist. Survey, xiii, pp. 329-338, pls. xl-xlv. (Descriptions of 8 new forms.)

SYNOPSIS OF THE SPECIES

1. Upper surface entirely bare and shining..... 9

   Upper surface, in part at least, more or less covered with scales, or sparse erect hairs, or with a bloom or "powder" (sometimes obscure in old or rubbed specimens)..... 2

2. Body above and beneath rather thickly covered by little yellowish scales which show a tendency to condense into broad stripes on the elytra .....*lanceolata*

   Body not covered with scales..... 3

3. Upper surface entirely devoid of hair, thorax shining, but elytra covered with a bloom or powder..... 4

   Upper surface with at least a few erect hairs, sometimes conspicuous ..... 5

4. Pronotum rather finely and closely punctured.....*crassissima*

   Pronotum coarsely and much less closely pitted.....*prunina*

5. Small, pale or yellowish species, 15 mm., or less in length..... 6

Large, dark, or reddish brown species, 17-25 mm. in length..... 7

6. Pronotum and elytra essentially similar in color and luster; hair long, dense and erect on pronotum and head, much shorter and recumbent on the elytra, except a few long hairs near the base.....*tristis*

Pronotum and elytra conspicuously different in color and luster, the former shining and nearly bare, the latter densely covered with a pale or whitish bloom, and almost devoid of luster....*lenis*

7. Pubescence of upper surface very sparse and inconspicuous, most evident on the pronotum.....*hirticula comosa*

Pubescence of upper surface conspicuous..... 8

8. Upper surface smooth and appearing highly polished under the hand lens; both of the terminal spurs of the hind tibiae jointed at the base, (17-20 mm.).....*crenulata*

Upper surface dulled by a fine bloom, which shows a slight iridescence under the hand lens; hind tibial spur next to the attachment of the tarsus jointed at the base, the outer spur fixed, (19-25 mm.).....*illicis*

9. Smaller (10-14 mm.), form slender and elongate, color yellow or testaceous ..... 10

Larger (15 + mm.), form more robust and oval, color darker, reddish brown to dark brown..... 11

10. Antennae always 9-jointed; fixed spur of hind tibiae of male short .....*longitarsa*

Antennae 10-jointed (rarely 9-jointed); fixed spur of hind tibiae of male long, blunt at the apex, distinctly curved and slightly twisted on its own axis.....*gracilis*

11. Antennae 9-jointed .....*implicita*

Antennae 10-jointed ..... 12

12. Males: Antennal club nearly as long as, or sometimes longer than, the preceding portion of the antenna; under surface of abdomen more or less flattened, grooved, or excavated on one or more segments..... 13

Females: Antennal club much shorter than the preceding portion of the antenna; under surface of abdomen usually smooth and convex ..... 26

13. Fixed spur of hind tibiae cylindrical and curved inwardly to the middle where it is suddenly flattened and sharply bent outwardly, the terminal portion being straight and tapering to the tip ..... *futilis*

Fixed spur of hind tibiae not sharply bent at the middle..... 14

14. Fixed spur of hind tibiae long, nearly parallel-sided, strongly, and roundly bent or bluntly hooked at the tip..... *vehemens*

Fixed spur of hind tibiae not strongly and roundly hooked at the tip ..... 15

15. Genital armature symmetrical, the claspers alike in size and shape ..... 25

Genital armature not symmetrical although sometimes nearly so ..... 16

16. Genital armature viewed from the end showing principally the elevated edges of the chitinous plates ..... 17

Genital armature viewed from the end showing principally broadened surfaces, the edges of the plates directed inwardly instead of being elevated..... 21

17. Under surface of abdomen with a longitudinal, sharply impressed line which divides the transverse ridge on the fifth abdominal sternite ..... *bipartita*

Under surface of abdomen without a sharply impressed longitudinal line ..... 18

18. Genital armature usually large, the terminal portion expanded, distinctly wider than the stalk of the armature..... 19

Genital armature much smaller, the terminal portion not expanded and scarcely, if any, wider than the narrowest portion of the stalk ..... 20

19. Hind tibial spurs large, very broad and flat, the widest portion of the movable spur distinctly wider than the basal third of the first tarsal joint ..... *horni*

Hind tibial spurs of average size and width, widest part of the movable spur not wider than the basal third of the first tarsal joint ..... *rugosa*

20. Pronotum very coarsely pitted, spurs of hind tibiae nearly equal in length ..... *corrosa*

Pronotum normally punctured, fixed spur of hind tibiae scarcely half as long as the movable spur.....*praetermissa*

21. Fifth abdominal sternite with a more or less well developed transverse ridge, the crest of which is usually somewhat darkened and roughened ..... 22

Fifth abdominal sternite without a transverse ridge, the longitudinal impression of the under surface of the abdomen ending on this sclerite in a well defined, slightly roughened depression, rear edge of the sternite distinctly emarginate or notched at the middle .....*inversa*

22. Transverse ridge of fifth sternite strongly and evenly arched in the middle, and with the ends of the ridge attaining or overhanging the rear margin of the segment.....*fervida*

Transverse ridge of fifth sternite much less strongly bent, the ends not attaining or overhanging the margin of the segment 23

23. Transverse ridge of the fifth sternite bisinuate behind, evenly rounded in front, and strongly roughened on the prominent, flattened middle portion .....*draki*

Transverse ridge of fifth sternite more or less arched instead of bisinuate behind..... 24

24. Terminal portion of genital armature rounded with the tips of the two sides turned inwardly and nearly or quite touching....*fusca*

Terminal portion of genital armature triangular with the tips of the two sides distinctly separated, not turned inwardly.....*anxia*

25. Last abdominal sternite with a median triangular impression, the posterior margin of the impressed area distinctly bilobed .....*congrua*

Last abdominal sternite not so modified, the posterior margin not bilobed at the middle.....*glabricula*

26. Pubic process absent, superior genital plates nearly as broad as the interior plates, united and keeled at the middle, emarginate at the end.....*futilis*

Pubic process present ..... 27

27. Pubic process distinctly divided, bilobed or split..... 29

Pubic process single..... 28

28. Pubic process as long as, or longer than, the supporting inferior plates ..... *congrua*

    Pubic process small, much shorter than the supporting plates.... *fusca*

29. Terminal portions of the pubic process rather long, slender, distinctly narrowed beyond the middle, and with the inner edges nearly parallel to the tips..... *inversa*

    Terminal portions of pubic process more or less distinctly divergent, the inner edges never parallel to the tip..... 30

30. Pubic process large, the basal portion distinctly larger and heavier than the terminal portion..... 31

    Pubic process smaller, the basal portion smaller than the terminal portion ..... 32

31. Pronotum coarsely and rather densely punctured, with a slightly elevated smooth, median line..... *rugosa*

    Pronotum less coarsely and densely punctured, and without the smooth line through the middle..... *horni*

32. Pronotum coarsely pitted..... *corrosa*

    Pronotum moderately or finely punctured..... 33

33. Pronotum viewed from above wider across the base than at the middle; larger species, length 19 – 22 mm..... 34

    Pronotum wider across the middle than at the base; smaller species, length 15 – 19 mm. ..... 35

34. Pubic process small and deeply divided, superior genital plates small; color usually dark or blackish brown..... *vehemens*

    Pubic process larger, less deeply divided, superior genital plates larger; color usually more of a reddish brown..... *draki*

35. Narrow rim or margin of sides of pronotum finely broken or serrated ..... 36

    Narrow rim of margin of sides of pronotum entire, not serrated ..... 37

36. Terminal portions of pubic process slenderer, somewhat tapering to their rounded tips..... *bipartita*

    Terminal portions of pubic process broader, not tapering, bluntly rounded or truncate at the ends..... *anxia*

37. Side margins of pronotum just in front of the hind angles slightly but distinctly emarginate; inferior and superior genital plates distinctly separated.....*fervida*

Side margins of pronotum not emarginate in front of the hind angles; inferior and superior genital plates not distinctly separated .....*praetermissa*

**Phyllophaga lanceolata** Say.

1824. *Melolontha lanceolata* Say, Journ. Acad. Nat. Sci. Phila., iii, p. 242. Le Conte ed., ii, p. 142.

Specimens examined: 26 ♂, 35 ♀, from South Bend, Lincoln, West Point, Brown Co., Thomas Co., Alliance, North Platte, Ogallala, McCook, Hitchcock Co., Imperial, Mitchell, and the Pine Ridge region of Sioux Co., collected from June 20 to August 27. *Lanceolata* is uncommon in eastern Nebraska, fairly common in the central part of the state, and abundant in the western counties, where in its larval, or white-grub, stage it is perhaps the most injurious species of the genus for the region. The beetles are diurnal, feeding in the open like potato beetles, and are found on weeds and herbaceous plants. The females lack the membranous wings and are very thick bodied. The males are distinctly smaller and fully winged.

**Phyllophaga praetermissa** Horn.

1887. *Lachnosterna praetermissa* Horn, Trans. Amer. Ent. Soc., xiv, p. 221.

Specimens examined: 29 ♂, 59 ♀, from Lincoln, Exeter, Hastings, Osceola, Central City, Grand Island and North Platte, collected from May 10 to June 26, at lights.

**Phyllophaga longitarsa** Say.

1824. *Melolontha longitarsa* Say, Journ. Acad. Nat. Sci. Phila., iii, p. 241. Le Conte ed., ii, p. 141.

Specimens examined: 6 ♂, 6 ♀, from Carns, Keyapaha Co., collected July 24, 1902 by W. D. Pierce.

**Phyllophaga gracilis** Burmeister.

1855. *Trichestes gracilis* Burmeister, Handbuch der Entomologie, iv, pt. 2, p. 361.

Specimens examined: 1 ♀, from Hogan's Bridge, Brown Co., August 3, 1902, collected by W. D. Pierce.

[**Phyllophaga glabricula** Le Conte.

1856. *Lachnosterna glabricula* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iii, p. 260.

No specimens of *glabricula* are at hand from Nebraska, but the species is not uncommon at Manhattan, Kansas. The species flies later in the season than most of the others, from the middle of June to the middle of August, and has probably on that account been overlooked in collecting. It doubtless occurs along the couthern border of the state.]

**Phyllophaga futilis** Le Conte.

1850. *Lachnosterna futilis* Le Conte, Agassiz Lake Superior, iv, p. 226.

Specimens examined: 400 ♂, 298 ♀, from Dakota City, Hooper, Ashland, West Point, Lincoln, Fairmont, Bradshaw, Osceola and Wood River, collected from May 10 to July 9. About half of the specimens were taken at lights, and 361 were taken on food plants as follows: elm, 276, dogwood 65, boxelder 5, prickly ash 4, rose 3, gooseberry 2, oak 2, willow 2, blackberry 1, and poplar 1. From this data it is readily apparent that *futilis* has a decided preference for elm. It is in fact our commonest species on that tree.

**Phyllophaga congrua** Le Conte.

1856. *Lachnosterna congrua* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iii, p. 243.

Specimens examined: 12 ♂, from Dakota City, Omaha and Lincoln, collected from May 21 to June 11, at lights.

**Phyllophaga prunina** Le Conte.

1856. *Lachnosterna prunina* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iii, p. 251.

Specimens examined: 1 ♂, from Ashland.

**Phylophaga crassissima** Blanchard.

1850. *Ancylonycha crassissima* Blanchard, Cat. de la coll. ent. Coléop. Mus. d'hist. nat. de Paris, p. 133.

Specimens examined: 3,532 ♂, 1,000 ♀, from Hooper, Fremont, Lincoln, Beatrice, Norfolk, Central City, Exeter, Hastings, Neligh, Holt Co., Grand Island, North Platte, Red Cloud and Wood River, collected from May 9 to August 1. By far the majority of these specimens were taken at lights, but the following food plant records are at hand: grasses and weeds, 134, *Amorpha canescens* 29, elm 24, blackberry 12, gooseberry, 6, dogwood 5, and boxelder 2. The preference of *crassissima* for grasses and weeds is significant. See notes under *rugosa*.

**Phyllophaga inversa** Horn.

1887. *Lachnosterna inversa* Horn, Trans. Amer. Ent. Soc., xiv, p. 241.

Specimens examined: 36 ♂, 8 ♀, from Maskell, West Point, Lincoln, Bradshaw, Osceola and Wood River, collected from May 19, to July 17. The only food plant record at hand is of a single female taken on the common weed *Amaranthus* sp.

**Phyllophaga bipartita** Horn.

1887. *Lachnosterna bipartita* Horn, Trans. Amer. Ent. Soc., xiv, p. 242.

Specimens examined: 134 ♂, 4 ♀, from Lincoln, Beatrice, Exeter and Red Cloud, collected from May to July 6, at lights.

**Phyllophaga vehemens** Horn.

1887. *Lachnosterna vehemens* Horn, Trans. Amer. Ent. Soc., xiv, p. 244.

Specimens examined: 168 ♂, 40 ♀, from Dakota City, Hooper, Fremont, Ashland, Lincoln, and Red Cloud, collected from April 21 to July 5, at lights and on the following food plants: poplar 14, willow 5, boxelder 4, elm 4. *Vehemens* is usually the first of our species to begin to fly in the spring, and while the flight continues for some time, the beetles are most in evidence in the earlier part of the season.

**Phyllophaga fusca** Froelich.

1792. *Melolontha fusca* Froelich, Naturforscher, xxvi, p. 99, pl. 3, fig. 3.

Specimens examined: 121 ♂, 185 ♀, from Nebraska City, Hooper, Fremont, Lincoln, Norfolk, West Point, Osceola, Bradshaw, Grand Island, Neligh, Halsey, Wood River and Red Cloud, collected from May 5 to July 9. A few specimens were taken on food plants as follows: dogwood 13, elm 11, ash 5, oak 2, gooseberry 1. *Fusca* is one of the comparatively few species in which the females seem to be more common than the males.

**Phyllophaga horni** Smith.

1889. *Lachnosterna hornii* Smith, Entomologica Americana, v, p. 95.

Specimens examined: 1 ♂, 2 ♀, from Lincoln, Nebraska City and Rulo, collected from April 26 to July 3. *Horni* is an eastern species the range of which probably does not extend far into the state.

**Phyllophaga fervida** Fabricius.

1781. *Melolontha fervida* Fabricius, Species Insectorum, i, p. 36.

Specimens examined: 7 ♂, from Fremont and Grand Island, collected at lights June 7 and 16, 1917.

**Phyllophaga anxia** Le Conte.

1850. *Lachnosterna anxia* Le Conte, Agassiz Lake Superior, iv, p. 226.

Specimens examined: 3 ♂, Lincoln, and Monroe Canyon in Sioux Co., collected from May 31 to June 28.

**Phyllophaga draki** Kirby.

1837. *Rhizotrogus drakii* Kirby, Fauna Boreali-Americana, part 4, p. 133.

Specimens examined: 1 ♂, 1 ♀, from Sioux Co. in June.

**Phyllophaga corrosa** Le Conte.

1856. *Lachnosterna corrosa* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iii, p. 249.

1920. *Lachnosterna corrosa* Hays and McColloch, Ann. Ent. Soc. Amer., xiii, p. 77, pl. viii.

Specimens examined: 76 ♂, 7 ♀, from Lincoln, West Point, Norfolk, Grand Island and Halsey, collected from May 18 to June 22. The only food plant record at hand is that of four specimens collected at Lincoln, feeding on *Amorpha canescens.*

In the Lincoln specimens the genital armature of the male is distinctly more angular in outline than in the other specimens here listed. Whether this variation is discontinuous or continuous is a point well worthy of future study because of its bearing upon specific and subspecific relationships.

**Phyllophaga rugosa** Melsheimer.

1844. *Ancylonycha rugosa* Melsheimer, Proc. Acad. Nat. Sci. Phila., ii, p. 140.

Specimens examined: 4,335 ♂, 462 ♀, from South Sioux City, Dakota City, Hooper, Fremont, Ashland, Nebraska City, Lincoln, Beatrice, West Point, Norfolk, Osceola, Neligh, Exeter, Fairmont, Bradshaw, Hastings, Grand Island, Halsey, Wood River and North Platte, col-

lected from May 10 to July 26. The great majority of the specimens were taken at lights, but the following food plant records were secured: elm 108, boxelder 64, *Amaranthus* 53, bluegrass, shepherd's purse and dandelion 51, willow 20, blackberry 10, poplar 9, oak 7, *Amorpha canescens* 1.

Since *rugosa* is doubtless the most destructive species in Nebraska cornfields, a significant point is brought out by the above data, namely that grasses and weeds, especially *Amaranthus,* prove highly attractive to the adult beetles. Since the females tend to lay their eggs close to the plants upon which they feed, it becomes evident that a weedy cornfield is much more liable to become infested than a clean one. Had the fondness of *rugosa* for *Amaranthus* been discovered earlier in the season during which most of the collecting was done, much more striking figures than the above could have been secured. The attractiveness of boxelder for this species is also worthy of note. See in this connection the food plant records under *crassissima.*

**Phyllophaga implicita** Horn.

1887. *Lachnosterna implicita* Horn, Trans. Amer. Ent. Soc., xiv, p. 262.

Specimens examined: 57 ♂, 138 ♀, from Lincoln, Nebraska City, Weeping Water, South Bend, Ashland, Fremont, Hooper, Dakota City, West Point, Norfolk, Osceola, Exeter, Fairmont, Neligh, Grand Island, Red Cloud, and Wood River, collected from May 9 to June 29. The following food plant records are at hand: elm 36, poplar 33 and willow 8.

**Phyllophaga hirticula comosa** Davis.

1920. *Phyllophaga hirticula comosa* Davis, Ill. Nat. Hist. Survey, xii, pp. 337-338, pl. xlv.

Specimens examined: 236 ♂, 127 ♀, from Lincoln, Ashland, Osceola and West Point. Food plant records are: oak 28, blackberry 15, *Amorpha canescens* 12, and elm 5.

**Phyllophaga ilicis** Knoch.

1801. *Melolontha ilicis* Knoch, Neue Beytrage zur Insectenkunde, p. 75, pl. i, fig. 28.

Specimens examined: 1 ♂, from Rulo, June 30, 1915, collected by L. Bruner.

**Phyllophaga crenulata** Froelich.

1792. *Melolontha crenulata* Froelich, Naturforscher, xxvi, pp. 92-94, pl. 3, fig. 2.

Specimens examined: 55 ♂, 40 ♀, from South Sioux City, Hooper, Ashland, West Point, Lincoln, Wood River and Halsey, collected from April to June 25. Most of the males were taken at lights and nearly all of the females feeding on foliage, distributed as follows: elm 14, dogwood 10, gooseberry 8, prickly ash 4.

**Phyllophaga tristis** Fabricius.

1781. *Melolontha tristis* Fabricius, Species Insectorum, i, p. 39.

Specimens examined: 21 ♂, 13 ♀, from South Bend, Lincoln, West Point, Halsey, Warren, and Chadron, collected from April 23 to May 19. Mr. H. H. Smith furnished the specimens from Warren, and reported that the species was flying in large numbers on the evening of May 19, 1918. On the same evening the heavy flight of *tristis* attracted the attention of Mr. L. M. Gates at Chadron, who sent in specimens for identification. Consequently even though comparatively few specimens are here recorded one may safely conclude that *tristis* is a rather common species in suitable localities over the state.

**Phyllophaga lenis** Horn.

1887. *Lachnosterna lenis* Horn, Trans. Amer. Ent. Soc., xiv, p. 287.

Specimens examined: 7 ♂, 7 ♀, from Lincoln, and Mitchell, collected from July to August 8. It may be that *lenis* is fairly common, but has been largely overlooked in collecting because of its late season of flight.

**Polyphylla** Harris

The males of the species in this genus have the antennal club enormously developed, often three or four times the length of the antennal stalk, while the females have the club of normal size. Specimens of the latter sex are usually difficult to find and are relatively rare in collections.

1842. Harris: Rept. Ins. Mass. Injurious to Vegetation, p. 30.

1856. Le Conte: "Synopsis of the Melolonthidae of the United States", Journ. Acad. Nat. Sci. Phila., (2) iii, pp. 225-288. (Descriptive notes on 6 species).

1881. Horn: "Revision of the Species of Polyphylla of the United States", Trans. Amer. Ent. Soc., ix, pp. 73-76. (Descriptive notes and table for 7 species).

1914. Casey: "A Review of the Genus Thyce and of the North American Species of Polyphylla", Memoirs on the Coleoptera, v, pp. 306-354. (Descriptive table for 49 forms).

SYNOPSIS OF THE SPECIES

1. Upper surface with conspicuous, longitudinal stripes of densely placed white scales, between the stripes the scales less closely placed and more or less yellowish, surface color largely obscured by the vestiture of scales.....*decemlineata*

   Upper surface obscurely striped, vestiture of scales not obscuring the brown surface color.....*hamondi*

**Polyphylla hamondi** Le Conte.

1856. *Polyphylla hamondi* Le Conte, Journ. Acad. Nat. Sci., Phila., (2), iii, p. 228.

Specimens examined: 10 ♂, from South Sioux City, Lincoln, North Platte, Carns, Brown Co., Halsey and Haigler, collected from July 1 to 22. *Hamondi* is also recorded from Illinois, Iowa and Kansas.

**Polyphylla decemlineata** Say.

1824. *Melolontha decemlineata* Say, Journ. Acad. Nat. Sci. Phila., iii, p. 246. Le Conte ed., ii, p. 145.

Specimens examined: 12 ♂, 5 ♀, from West Point, Neligh, Thedford, and Sioux Co. This species is much commoner westwardly, probably not occurring further to the east than West Point. Its range as limited by Mr. Casey extends over Nebraska, Kansas, Colorado and New Mexico.

### Macrodactylini

Front coxae conical and prominent; abdominal segments freely articulated; labrum not connate with the clypeus; ligulae closely united with the mentum.

#### **Dichelonyx** Harris

1826. Harris: Mass. Agr. Repository, x, p. 6.

1837. Kirby: Fauna Boreali-Americana, iv, p. 133. Ibid. Can. Ent., iii, p. 211.

1856. Le Conte: "Synopsis of the Melolonthidae of the United States", Journ. Acad. Nat. Sci. Phila., (2), iii, pp. 225-288. (Descriptive notes on 13 species).

1876. Horn: "Revision of the United States Species of Ochodaeus and other Genera of Scarabaeidae", Trans. Amer. Ent. Soc., v, pp. 177-197. (Table and descriptive notes for 15 species).

1901. Fall: "Notes on Dichelonycha and Cantharis, with Descriptions of New Species in Other Genera", Trans. Amer. Ent. Soc., xxvii, pp. 277-310. (Table and descriptive notes for 25 species).

1910. Blatchley: Coleoptera of Indiana, pp. 951-953. (Table and descriptive notes for 6 species).

SYNOPSIS OF THE SPECIES

1. Clypeal angles rectangular; length 6 – 8 mm. ..... *truncata*

   Clypeal angles rounded; length 8 – 12 mm. ..... 2

2. Margin of clypeus broadly reflexed; color uniformly testaceous ..... *testacea*

Margin of clypeus narrowly reflexed; elytra with a more or less well marked greenish or purple luster..... 3

3. Elytra with a darker stripe near the sides, more pronounced at the extremities; inner spur of hind tibiae of male with sides nearly parallel, and the tip blunt; hind tibiae testaceous..*subvittata*

Elytra without a darker stripe; inner spur of hind tibiae of male similar to the outer spur; hind tibiae more or less blackened at the apex.....*elongata*

**Dichelonyx elongata** Fabricius.

1792. *Melolontha elongata* Fabricius, Entomologia systematica, i, pt. 2, p. 170.

Specimens examined: 6 ♂, 11 ♀, from Omaha, Bellevue and Lincoln, collected during the month of May. This is a common eastern species the range of which probably does not extend across Nebraska to the westward.

**Dichelonyx subvittata** Le Conte.

1856. *Dichelonycha subvittata* Le Conte, Journ. Acad. Nat. Sci. Phila, (2), iii, p. 279.

Specimens examined: 6 ♂, 5 ♀, from Rulo, South Bend, Lincoln, and West Point, collected from May 22 to July 2. *Subvittata* like the preceding species is of eastern distribution.

**Dichelonyx testacea** Kirby.

1837. *Dichelonycha testacea* Kirby, Fauna Boreali-Americana, iv, p. 135. Ibid. Can. Ent., iii, p. 213.

Specimens examined: 16 ♂, 12 ♀, from West Point, "Pine Ridge", Warbonnet and Monroe canyons in Sioux Co., collected from May to July. *Testacea* ranges in Nebraska from the north.

**Dichelonyx truncata** Le Conte.

1856. *Dichelonycha truncata* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iii, p. 281.

Specimens examined: 71 ♂, 4 ♀, from Mitchell and

Warbonnet and Monroe canyons in Sioux Co., collected during the month of June. *Truncata* is a common western species reaching the state from that direction.

**Macrodactylus** Latreille

1825. Latreille: Familles naturelles du règne animal, p. 271.

1856. Le Conte: "Synopsis of the Melolonthidae of the United States", Journ. Acad. Nat. Sci. Phila., (2), iii, pp. 225-288. (Descriptive notes on 3 species).

1876. Horn: "Revision of the United States Species of Ochodaeus and other Genera of Scarabaeidae", Trans. Amer. Ent. Soc., v, pp. 177-197. (Table and descriptive notes for 3 species).

1910. Blatchley: Coleoptera of Indiana, pp. 953-954. (Descriptions for 2 species).

**Macrodactylus subspinosus** Fabricius.

1775. *Melolontha subspinosus* Fabricius, Systema Entomologiae, p. 39.

Specimens examined: 61 ♂, 64 ♀, from West Point, Scribner, Neligh, Halsey, Broken Bow, Keya Paha Co., Valentine, Cherry Co., "Pine Ridge", Imperial, Ogallala and Ainsworth, collected from June 3 to July 5. This is a destructive and widely distributed species, occurring abundantly during June and early July in central and western Nebraska.

HOPLIINI

Body more or less covered with yellow, brown or silvery scales; abdominal segments closely united; tibiae with only one spur; hind tarsi with a single large claw; front coxae large and prominent; larbum concealed beneath the clypeus.

**Hoplia** Illiger

1803. Illiger: Magazin für Insectenkunde, ii, p. 226.

1856. Le Conte: "Synopsis of the Melolonthidae of the United States", Journ. Acad. Nat. Sci. Phila., (2), iii, pp. 225-288. (Descriptive Notes on 12 species).

1880. Le Conte: "Short Studies of North American Coleoptera", Trans. Amer. Ent. Soc., viii, pp. 163-218. (Table, synonymy and notes for 12 species).

1910. Blatchley: Coleoptera of Indiana, pp. 949-950. (Table and notes for 5 forms).

**Hoplia laticollis** Le Conte.

1856. *Hoplia laticollis* Le Conte, Journ. Acad. Nat. Sci. Phila., (2), iii, p. 284

Specimens examined: 105 ♂, 6 ♀, from Lincoln, West Point, Holt Co., Spring View Bridge, Dewey Lake in Cherry Co., "Pine Ridge", Glen, and Monroe Canyon in Sioux Co., collected during June. *Laticollis* is apparently much commoner westwardly in the state. On June 26, 1911 the writer found it fairly swarming on a moist sandy road side in Monroe Canyon where in a few moments fifty-five specimens were taken, and several times as many more still remained on the sand. The following day the beetles had deserted the spot and the species was not again seen during the remaining ten days spent in the canyon.

PLEUROSTICTI

Abdominal spiracles, except the anterior ones, situated in the dorsal portion of the sternites, forming rows which diverge strongly; last spiracle usually visible behind the elytra; ligulae always firmly united with the mentum.

RUTELINI

Claws of all of the tarsi more or less unequal in size or shape, the difference sometimes slight.

**Anomala** Samouelle

1819. Samouelle: The Entomologists Useful Compendium, p. 191.

1884. Horn: "Notes on the Species of Anomala Inhabiting the United States", Trans. Amer. Ent. Soc., xi, pp. 157-164. (Table and descriptive notes for 12 species).

1906. Schaeffer. "Notes on Some Species of the Genus Anomala with Descriptions of New Species", Journ. N. Y. Ent. Soc., xiv, pp. 1-5. (Notes on 11 species).

1907. Schaeffer: "New Scarabaeidae", Journ. N. Y. Ent. Soc., xv, pp. 60-75. (Table to 22 species).

1910. Blatchley: Coleoptera of Indiana, pp. 981-985. (Table and descriptive notes for 8 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 5-48. (Descriptive table for 62 forms).

SYNOPSIS OF THE SPECIES

1. Above yellowish testaceous, head, anterior portion of pronotum medially, and the scutellum a little darker.....*apacheana*

   Head, pronotum and sometimes the elytra, largely dark brown or black ..... 2

2. Large species, length 10 – 12 mm.; elytra brown, usually with a well-marked dark spot a little before the middle of each..*binotata*

   Smaller species, length 6.5 – 9 mm. ..... 3

3. Pygidium thinly clothed with pallid hairs; elytra light brown with the punctures and striae blackish; length about 8 mm. .....*ludoviciana*

   Pygidium bare, or with only a few apical hairs; elytra varying from largely light brown to entirely black; length about 7 mm. .....*innuba*

**Anomala apacheana** Wickham.

1913. *Anomala apacheana* Wickham, Psyche, xx, pp. 30-31.

Specimens examined: 1 ♂, taken at Haigler, July 5, 1911 by J. T. Zimmer. This species has been known only by the unique type, a male, taken at El Paso, Texas on July 9, by Mr. Wickham.

**Anomala binotata** Gyllenhal.

1827. *Melolontha binotata* Gyllenhal, Appendix to Schonherr's Synonymia Insectorum, p. 106.

Specimens examined: 34 ♂, 25 ♀, from Omaha, Pender, South Bend, Lincoln, West Point and Halsey, collected from May 10 to June 13. *Binotata* is an abundant and widely distributed species.

**Anomala ludoviciana** Schaeffer.

1906. *Anomala ludoviciana* Schaeffer, Journ. N. Y. Ent. Soc., xiv, p. 3.

Specimens examined: 8 ♂, from South Sioux City, South Bend, Norfolk, West Point, Neligh and the "Sand Hills", collected from June 24 to July 7.

**Anomala innuba** Fabricius.

1787. *Melolontha innuba* Fabricius, Mantissa Insectorum, i, p. 22.

Specimens examined: 10 ♂, from Lincoln, West Point and Fairmont, collected from June 21 to July 2. In this as well as several other species of the genus *Anomala* the color of the elytra seems to be inconstant. The majority of the specimens at hand have the elytra wholly black, but they vary from this condition to slightly streaked with brown, heavily streaked, or largely brown. *Innuba* is fairly common throughout most of the eastern and southern states.

**Strigoderma** Burmeister

1844. Burmeister: Handbuch der Entomologie, iv, pt. i, p. 310.

1907. Schaeffer: "New Scarabaeidae", Journ. N. Y. Ent. Soc., xv, pp. 60-75. (Descriptive notes and table for 5 species).

1910. Blatchley: Coleoptera of Indiana, pp. 985-986. (Description of *arboricola).*

1915. Casey: Memoirs on the Coleoptera, vi, pp. 48-62. (Descriptive table for 16 forms).

**Strigoderma arboricola** Fabricius.

1801. *Melolontha arboricola* Fabricius, Systema Eleutheratorum, ii, p. 174.

Specimens examined: 50 from South Bend, Louisville, Meadow, Cedar Bluffs, West Point, Neligh, Keya Paha Co., Brown Co., Cherry Co., Halsey, Dismal River, Haigler and Imperial, collected from June 16 to July 6. There is an inconstant tendency for the fourth and eighth elytral ridges to become stronger than the others.

**Pelidnota** Mac Leay

1819. Mac Leay: Horae Entomologicae, p, 157.

1915. Casey: Memoirs on the Coleoptera, vi, pp. 68-76. (Descriptive table to 16 forms).

**Pelidnota punctata** Linnaeus.

1758. *Scarabaeus punctatus* Linnaeus, Systema Naturae, ed. x, p. 350.

1910. *Pelidnota punctata* Blatchley, Coleoptera of Indiana, p. 986.

Specimens examined: 20 ♂, 24 ♀, from Rulo, Nebraska City, Omaha, and Lincoln, collected from June 16 to August 24, on grape vines, Virginia creeper and at lights. In the series at hand the length varies from 18 to 24 mm., the color from pale yellow to reddish brown, and the three elytral, black spots from small or partially obsolete to very heavy.

**Cotalpa** Burmeister

1844. Burmeister: Handbuch der Entomologie, iv, pt. i, p. 423.

1867. Horn: "Descriptions of New Genera and Species of Western Scarabaeidae, with Notes on Others Already Known", Trans. Amer. Ent. Soc., i, pp. 163-170. (Table to 4 species).

1871. Horn: "Descriptions of new Coleoptera of the United States, with Notes on Known Species", Trans. Amer. Ent. Soc., iii, pp. 325-344. (Table to 5 species).

1905. Wickham: "The North American Species of Cotalpa", Journ. N. Y. Ent. Soc., xiii, pp. 1-4. (Table to 7 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 88-98. (Descriptive table for 18 forms).

SYNOPSIS OF THE SPECIES

1. Head smaller, width including the eyes about 4 mm.; punctures of elytra coarser and more closely placed, showing a strong tendency to be connected by shallow grooves or wrinkles, especially at the inner basal portion; scutellum more narrowly triangular ..... *subcribrata*

   Head larger, width including the eyes about 5 mm.; punctures of elytra distinctly smaller, and more sparsely placed, and not irregularly connected by shallow wrinkles; scutellum more broadly triangular ..... *lanigera*

**Cotalpa subcribrata** Wickham.

1905. *Cotalpa subcribrata* Wickham, Journ. N. Y. Ent. Soc., xiii, pp. 2-3.

Specimens examined: 37, from Omaha, Brady Island, Cherry Co., Halsey and Oshkosh, collected from May 19 to June 7. *Subscribrata* was described from Mendora, Kansas, and is apparently common in our Sand Hills region.

**Cotalpa lanigera** Linnaeus.

1758. *Scarabaeus lanigera* Linnaeus, Systema Naturae, ed. x, p. 350.

Specimens examined: 14, from Meadow, Nebraska City, South Bend, Fremont, West Point, Richland, Neligh, and Grand Island, collected from May 22 to July 3.

DYNASTINI

Claws of the tarsi, except the front ones of many males, equal; front coxae transverse and not prominent; labrum usually hidden under the clypeus; head and pronotum often more or less armed.

**Cyclocephala** Latreille

1829. Latreille: Cuvier's Règne animal, ed. 2.

1863. Le Conte: "New Species of North American Coleoptera", Smithsonian Miscellaneous Collections, pt. i, pp. 79-80. (Table and descriptive notes for 7 species).

1871. Horn: "Descriptions of New Coleoptera of the United States, with Notes on Known Species", Trans. Amer. Ent. Soc., iii, pp. 325-344. (Table and descriptive notes for 9 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 124-158. (Descriptive table for 33 forms).

SYNOPSIS OF THE SPECIES

1. Clypeal suture rather strongly arched medially; sides of clypeus subparallel basally, and more abruptly convergent apically; general color paler.....*hirta*

   Clypeal suture nearly straight; sides of clypeus almost evenly, arcuately convergent apically; general color darker..... 2

2. Claws of anterior tarsi equal in size and similar to those of the middle and hind tarsi (females)..... 5

   Claws of anterior tarsi unequal in size; the front claw very much broader and more strongly bent (males)..... 3

3. Elytra with sparse, erect, yellow hairs, largely confined to the nearly obsolete costae; pygidium and body beneath with somewhat denser and longer hairs.....*villosa*

   Elytra bare except for a few short hairs at the apex and the usual short marginal hairs..... 4

4. Club of antenna distinctly longer than the stalk; claspers of genital armature emarginate at the middle of the outer side *longula*

   Club of antenna shorter than the stalk; claspers of genital armature emarginate just beyond the middle of the outer side, and with the emargination emphasized basally by a strong, oblique lobe or tooth.....*immaculata*

5. Side margin of the elytra slightly but distinctly widened or explanate just above the outer end of the hind coxal plates..... 6

   Side margin of the elytra plain and unmodified.....*longula*

6. Elytra much more strongly and coarsely sculptured, the large punctures tending to coalesce; sides of elytra but little or not at all clouded; body relatively shorter and broader in form....*villosa*

   Elytra less strongly and coarsely sculptured, the punctures smaller and more distinctly separated; sides of elytra immedi-

ately above and behind the explanate portion of the margin with a distinct, elongate and posteriorly evanescent dark spot ..... *immaculata*

**Cyclocephala hirta** Le Conte.

1861. *Cyclocephala hirta* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 346.

Specimens examined: 7 ♀, from Lincoln and Maskell, collected from June to August.

**Cyclocephala villosa** Burmeister.

1856. *Cyclocephala villosa* Burmeister, Handbuch der Entomologie, v, p. 54.

Specimens examined: 5 ♂, 4 ♀, from Lincoln, collected during June and early July.

**Cyclocephala longula** Le Conte.

1863. *Cyclocephala longula* Le Conte, Smithsonian Miscellaneous Collections, New Species, pt. i, p. 79.

Specimens examined: 1 ♂, from Haigler, collected July 5, 1911 by J. T. Zimmer.

**Cyclocephala immaculata** Olivier.

1789. *Melolontha immaculata* Olivier, Encyclopédie Méthodique, Insectes, v, p. 29, pl. 8, fig. 95.

Specimens examined: 120 ♂, 57 ♀, from Omaha, South Bend, Lincoln, Wymore, Fairmont and York, collected from May 3 to July 28.

**Dyscinetus** Harold .

1869. Harold: L'Abeille, vi, p. 123.
1915. Casey: Memoirs on the Coleoptera, vi, pp. 165-173. (Descriptive table for 6 forms).

SYNOPSIS OF THE SPECIES

1. Pygidium with coarse, distinctly separated punctures; clypeus

with shallow punctures which coalesce transversely and form wrinkles ..... *puncticauda*

Pygidium finely and very densely wrinkled or roughened; clypeus finely and sparsely punctate..... *trachypygus*

**Dyscinetus puncticauda** Casey.

1909. *Dyscinetus puncticauda* Casey, Can. Ent., xli, p. 282.

Specimens examined: 5 ♂, 4 ♀, from Culbertson, North Platte, Gothenburg and Red Cloud, collected from June 13 to July 3, at lights. This is probably a very common species through central and western Nebraska.

**Dyscinetus trachypygus** Burmeister.

1856. *Chalepus trachypygus* Burmeister, Handbuch der Entomologie, v, p. 79.

Specimens examined: 1 ♂, 1 ♀, from Lincoln, collected in May and June at lights.

**Ligyrodes** Casey

1915. Casey: Memoirs on the Coleoptera, vi, pp. 178-186. (Descriptive table for 5 forms).

SYNOPSIS OF THE SPECIES

1. Pronotum and elytra black or piceous, moderately shining; clypeal apex broader, less elevated and more deeply emarginate; median, external tooth of mandibles less strongly and acutely produced; male genital armature with the subterminal, lateral tooth of the claspers nearly as broad basally as high..... *relictus*

Pronotum piceous to black, elytra dark red, surface more strongly polished and shining; clypeal apex much narrower and more strongly elevated, and less deeply emarginate; median external tooth of mandibles more strongly and acutely produced; male genital armature with the subterminal, lateral tooth of the claspers only half as broad basally as high ..... n. sp. in MS Casey

**Ligyrodes relictus** Say.

1823. *Scarabaeus relictus* Say, Journ. Acad. Nat. Sci. Phila., v, p. 194. Le Conte ed., ii, pp. 296-297.

Specimens examined: 43 ♂, 45 ♀, from South Sioux City, Omaha, South Bend, Lincoln, Neligh, Halsey and McCook, collected from April 22 to October 7, mostly at lights.

**Ligyrodes** n. sp. in Ms. by Casey.

Specimens examined: 2 ♂, 1 ♀, from South Sioux City, collected from June 10 to July 8, 1912 by L. T. Williams.

**Ligyrus** Burmeister

1847. Burmeister: Handbuch der Entomologie, v, p. 542.

1875. Horn: "Synonymical Notes and Descriptions of New Species of North American Coleoptera", Trans. Amer. Ent. Soc., v, pp. 126-156. (Table to 4 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 186-209. (Descriptive table to 33 forms).

SYNOPSIS OF THE SPECIES

1. Pronotum with an anterior, median impression and a blunt tubercle at the front margin of the impression; color brown, moderately shining ..... *gibbosus*

   Pronotum without the anterior impression and blunt tubercle; color black and not very shining..... *rugiceps*

**Ligyrus rugiceps** Le Conte.

1856. *Ligyrus rugiceps* Le Conte, Proc. Acad. Nat. Sci. Phila., viii, p. 21.

Specimens examined: 1 ♂, 1 ♀, from Lincoln, the female without further data, and the male labeled "July 7, 1914, E. M. Partridge". *Rugiceps* is an abundant and destructive species in the southern states, Georgia to Texas, where it is called the Sugar-cane Beetle because of its injury to that plant. Corn is frequntly killed by the burrowing of this insect into the base of the stalk below the surface of the soil.

**Ligyrus gibbosus** De Geer.

1768. *Scarabaeus gibbosus* De Geer, Mémoires pour servir à l' histoire des Insectes, iv, p. 322.

Specimens examined: 124, from Maskell, Omaha, Ashland, Nebraska City, Lincoln, West Point, Norfolk, Neligh, Fairmont, Bradshaw, Minden, Ravenna, McCook, and Mitchell. *Gibbosus* is an abundant widely distributed and rather variable species. It is commonly called the Carrot Beetle, because it frequently injures the roots of that plant. It is also destructive to beets, potatoes, parsnips and corn. The larvae are recorded as occuring in numbers around well rotted manure piles.

**Aphonus** Le Conte.

1856. Le Conte: Proc. Acad. Nat. Sci. Phila., viii, p. 21.

1915. Casey: Memoirs on the Coleoptera, vi, pp. 210-222. (Descriptive table for 18 forms).

**Aphonus pyriformis** Le Conte.

1847. *Bothynus pyriformis* Le Conte, Journ. Acad. Nat. Sci., Phila., (2), i, p. 88.

Specimens examined: 2♂, 6♀, from Minden, Oxford, Mitchell, Glen, and Sioux Co., collected from May 18 to July 20.

CETONIINI

Claws equal and simple; front coxae conical and prominent; Mandibles and labrum always covered by the clypeus; pygidium not covered by the elytra; epimera of mesothorax often visible from above at the sides of the elytra.

**Euphoria** Burmeister

1843. Burmeister: Handbuch der Entomologie, iii, p. 370.

1880. Horn: "Synopsis of the Euphoriae of the United States", Proc. Amer. Philos. Soc., xviii, pp. 398-408. (Table and descriptive notes for 14 species).

1910. Blatchley: Coleoptera of Indiana, pp. 997-999. (Table and notes for 5 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 299-339. (Descriptive table to 38 forms).

SYNOPSIS OF THE SPECIES

1. Clypeal margin provided with four sharp, reflexed points or teeth ..... *pilipennis*

   Clypeal margin not dentate..... 2

2. Upper surface polished, iridescent green and cupreous; pronotum entirely bare; length 14 – 17 mm.; pygidium with a transverse row of four, large, rounded, pale, tomentose spots..... *fulgida*

   Upper surface opaque, or moderately shining; pronotum distinctly pubescent ..... 3

3. Pronotum without lateral beading; hind tibiae of male with a long and very dense brush of hairs on the inner side..... *hirtipes*

   Pronotum with distinct lateral beading; hind tibiae of male normal ..... 4

4. Pronotum densely pubescent,the dark surface color largely obscured by the short, pale hairs; elytra brown, with blackish mottlings which often show a tendency to be arranged in longitudinal rows ..... *inda*

   Pronotum not densely pubescent..... 5

5. Upper surface nearly black, shining, with a bronzed or greenish luster; elytra with well-separated, undulate and broken transverse lines of grayish tomentum..... *sepulchralis*

   Upper surface black or not, but without a greenish or metallic luster, and elytra without the transverse, undulate lines of tomentum ..... *kerni*

   A. Pronotum black margined at the sides and base with yellow, elytra yellow heavily and more or less confluently maculated, especially toward the center, with black.....variety *kerni*

   B. Abdomen and legs largely yellow or fulvous, upper surface similar to that in the variety *kerni*, but less heavily maculated, and with the black area of the pronotum more or less divided medially and strongly notched at the sides anteriorly by the yellow or fulvous border.....variety *clarki*

C. Black above and beneath.....variety *texana*

**Euphoria fulgida** Fabricius.

1775. *Cetonia fulgida* Fabricius, Systema Entomologiae, p. 48.

Specimens examined: 5 ♂, from Omaha and South Bend, collected during June and early July, on oak leaves. *Fulgida* is a common and widely distributed species. In life it possesses an astonishingly brilliant and beautiful opalescent quality of coloration, a large part of which is lost in the dried specimens.

**Euphoria inda** Linnaeus.

1758. *Scarabaeus indus* Linnaeus, Systema Naturae, ed. x, p. 352.

Specimens examined: 52 ♂, 26 ♀, from Louisville, South Bend, Ashland, Omaha, Fremont, Lincoln, West Point, Holdrege, Halsey, Haigler, Sidney, Mitchell and Monroe Canyon in Sioux Co., collected from March 30 to October. *Inda* is an abundant and widely distributed species, ranging from New York to California. A considerable amount of variation occurs, apparently correlated with the geographical distribution of the species. With a sufficient quantity of material at hand one could doubtless define a number of valid races, just as the ornithologists have done with the horned larks, song sparrows and others. In Nebraska two types of *inda* are recognizable, one with the upper surface distinctly shining as in the specimens received from New York, and the other very opaque and lusterless. The former occurs clear across the state, while the latter seems to be much less common eastwardly.

**Euphoria kerni kerni** Haldeman.

1852. *Euphoria kerni* Haldeman, Insects of Stansbury's Expl. and Surv. Great Salt Lake Valley, p. 374, pl. 9, fig. 10.

Specimens examined: 8 ♂, 23 ♀, from McCook, Curtis and Hitchcock Co., collected during June and early July, mostly on cactus blossoms.

**Euphoria kerni clarki** Le Conte.
1853. *Erirhipis clarki* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 441.

Specimens examined: 5 ♀, from McCook and Hitchcock Co., collected along with the specimens just listed under the from the type locality (Cache la), Poudre River, Colorado. more heavily wooded districts.]

**Euphoria kerni texana** Schaufuss.
1863. *Euphoria texana* Schaufuss, Sitz. Ges. Isis, p. 113.

Specimens examined: 5 ♂, 3 ♀, from Curtis, McCook and Hitchcock Co., collected along with the specimens listed for the two preceding varieties.

The writer has preferred Dr. Horn's long accepted view, that these forms all belong to a single exceedingly variable species. Several specimens at hand from Colorado are exactly intermediate between *kerni* and *clarki*, and some of the specimens of *texana* show evident traces of the pale thoracic margins and elytral spots characteristic of the lighter forms. No evident structural characters are correlated with the color differences, the genital armatures of the males are identical in form, and all of the varieties occur together on the same flowers. The names therefore probably have but little taxonomic value, and are retained only for convenience in designating color variations.

**Euphoria sepulchralis** Fabricius.
1801. *Cetonia sepulchralis* Fabricius, Systema Eleutheratorum, ii, p. 156.

Specimens examined: 1 ♂, from Rulo, collected July 2, 1915 by E. M. Partridge. *Sepulchralis* is a very common species in the southern states.

**Euphoria hirtipes** Horn.
1880. *Euphoria hirtipes* Horn, Proc. Amer. Philos. Soc., xviii, pp. 398, 401.

Specimens examined: 44 ♂, 38 ♀, from West Point and Halsey, collected during April and May in ant nests.

**Euphoria pilipennis** Kraatz.

1883. *Stephanucha pilipennis* Kraatz, Berl. Ent. Zeitschr., xxviii, p. 384.

Specimens examined: 23 ♂, 14 ♀, from Lincoln, West Point, Holt Co., Sand Hills, Halsey and Haigler, collected from April 26 to September. In this species the elytra vary from pure black to heavily and confluently maculated with fulvous, and the pygidium may be either entirely black or with two more or less well-marked, pale, tomentose areas. *Pilipennis* is closely related to the eastern species *areata*, and may possibly be only subspecifically distinct.

### **Cremastochilus** Knoch

1801. Knoch: Neue Beyträge zur Insectenkunde, p. 115.

1871. Horn: "Descriptions of new Coleoptera of the United States, with Notes on Known Species", Trans. Amer. Ent. Soc., iii, pp. 325-344. (Table for 12 species and 2 descriptions).

1880. Horn: "Monographic Revision of the Species of Cremastochilus and Synopsis of the Euphoriae of the United States", Proc. Amer. Philos. Soc., xviii, pp. 382-408. (Table and descriptions for 17 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 340-370. (Descriptive table for 42 forms).

#### SYNOPSIS OF THE SPECIES

1. Reflexed rim of mentum deeply and broadly divided at the middle behind ..... *retractus*

   Reflexed rim of mentum entire behind..... 2

2. Ventral surface of abdomen opaque, the first four segments with narrow yellowish margins, surface conspicuously pubescent, the hairs short, very coarse, plumose and yellowish or pale fulvous in color..... *wheeleri*

   Ventral surface more or less shining, hairs simple, often inconspicuous or wanting..... 3

3. Pronotum with the sides distinctly set off from the discal area by rather strong, longitudinal depressions; color reddish brown ..... *saucius*

   Pronotum without longitudinal impressions defining a discal area ..... 4

4. Posterior angles of pronotum continuous with the side margins; upper surface of body dull black..... *knochi*

   Posterior angles of pronotum not continuous with the side margins, separated by a very deep and strong, oblique groove; upper surface strongly shining..... *nitens*

**Cremastochilus retractus** Le Conte.

1874. *Cremastochilus retractus* Le Conte, Trans. Amer. Ent. Soc., v, pp. 54-55.

Specimens examined: 1, from Halsey in June.

**Cremastochilus nitens** Le Conte.

1853. *Cremastochilus nitens* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 232.

Specimens examined: 36, from South Bend, West Point, Brady Island and Halsey, collected from May 5 to June 20.

**Cremastochilus knochi** Le Conte.

1853. *Cremastochilus knochii* Le Conte, Proc. Acad. Nat. Sci. Phila., p. 231.

Specimens examined: 69, from Omaha, South Bend, Lincoln, Fairmont, West Point, Cherry Co., Crawford, Monroe Canyon in Sioux Co., and Mitchell collected from March to September 12.

**Cremastochilus saucius** Le Conte.

1858. *Cremastochilus saucius* Le Conte, Journ. Acad. Nat. Sci. Phila., iv, p. 16.

Specimens examined: 1, from Haigler, May 23, 1914, collected by L. M. Gates. *Saucius* is recorded from Kansas and Colorado, and is probably not uncommon in the southwestern part of the state.

**Cremastochilus wheeleri** Le Conte.

1876. *Cremastochilus wheeleri* Le Conte, Ann. Rept. Ch. Eng. App. jj. p. 516.

Specimens examined: 9, from Lincoln, West Point, Halsey and Glen, collected from May to July 12.

**Osmoderma** Serville

1825. Serville: Entomological part of Encyclopédie méthodique, x, p. 702.

1910. Blatchley: Coleoptera of Indiana, pp. 1001-1002. (Descriptive notes on 2 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 372-377. (Descriptive table for 8 forms).

SYNOPSIS OF THE SPECIES

1. Dorsal surface roughly and coarsely sculptured.....[*scaber*]

   Dorsal surface smooth or with the sculpture comparatively fine and sparse .....*eremicola*

[**Osmoderma scaber** Beauvois.

1805. *Trichius scaber* Beauvois, Insectes recueillis en Afrique et en Amerique, p. 58.

No specimens are at hand from Nebraska, but the species probably occurs along the Missouri River especially in the more heavily wooded districts.]

**Osmoderma eremicola** Knoch.

1801. *Cetonia eremicola* Knoch, Neue Beyträge zur Insectenkunde, p. 105.

Specimens examined: 2, from Warbonnet Canyon in Sioux Co., in July, and Monroe Canyon, August 27, 1908 (C. H. Gable).

**Trichius** Fabricius

1775. Fabricius: Systema Entomologiae, p. 40.

1876. Horn: "Revision of the United States Species of Ochodaeus and other Genera of Scarabaeidae", Trans. Amer. Ent. Soc., v, pp. 177-197. (Table and descriptive notes for 6 species).

1910. Blatchley: Coleoptera of Indiana, pp. 1003-1004. (Table and descriptive notes for 3 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 380-391. (Descriptive table for 19 forms).

**Trichius piger** Fabricius.

1775. *Trichius piger* Fabricius, Systema Entomologiae, p. 41.

Specimens examined: 107 ♂, 19 ♀, from South Sioux City, Omaha, Bellevue, Meadow, South Bend, Nebraska City, Rulo and Lincoln, collected from May 30 to August, feeding in numbers on wild rose blossoms.

**Valgus** Scriba

1790. Scriba: Journal fur die Liebhaber der Entomologie, Frankfort, pt. i, p. 66.

1910. Blatchley: Coleoptera of Indiana, pp. 1004-1005. (Table and descriptive notes for 2 species).

1915. Casey: Memoirs on the Coleoptera, vi, pp. 391-394. (Descriptive table for 4 forms).

**Valgus squamiger** Beauvois.

1805. *Valgus squamiger* Beauvois, Insectes recueillis en Afrique et en Amérique, p. 59.

Specimens examined: 1 ♀, from South Bend. The species of this genus are recorded as hibernating beneath mullein leaves and in decaying wood, and later frequenting the flowers of red haw and dogwood.

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